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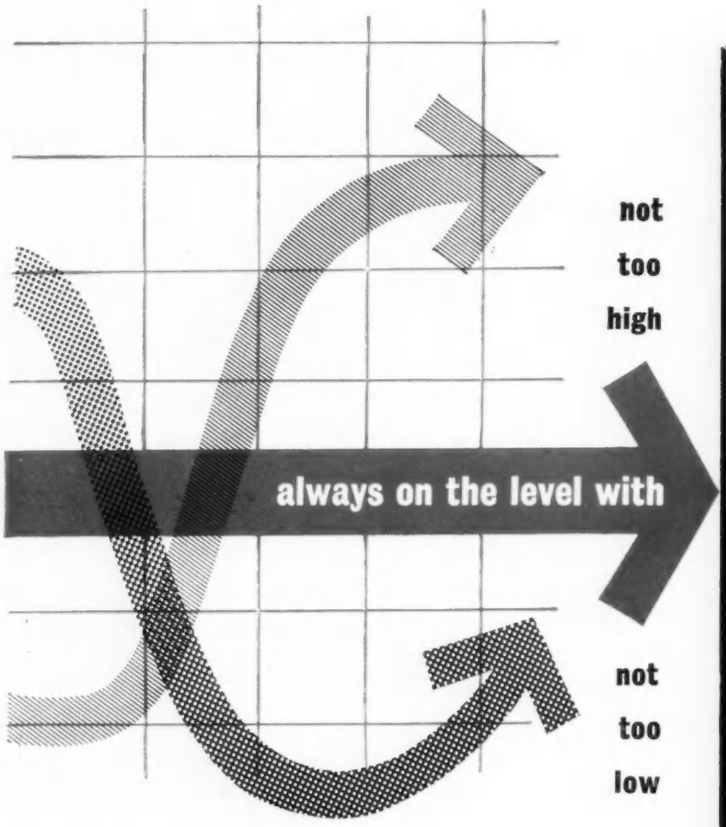

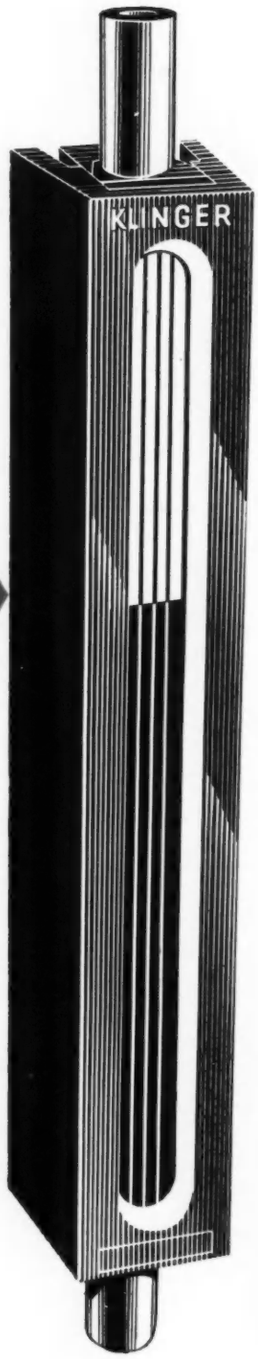

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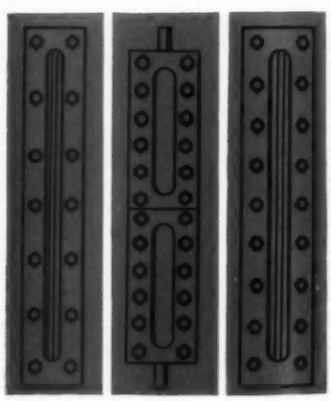

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No. 5481 · **FEBRUARY 10, 1961** VOL. 211

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SUBSCRIPTIONS U.K. and ABROAD £5 10. 0. p.a., including postage (CANADA £5 5. 0.). Single copies 2s. each, plus 9d. postage. Also on sale at newsagents.

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DO ECONOMISTS UNDERSTAND IT?

Since the opening of this new year there has been a good deal of comment and discussion in chairmen's reports to shareholders, in after-dinner speeches and in the Press, of the economic situation of this country. On Monday of this week the House of Commons debated it. Particularly has attention been drawn to what is regarded as Britain's poor showing in export markets. In comparison with last year the exports of manufactures by the United Kingdom in the period January-September rose by 9 per cent, as compared with no less than 48 per cent for Italy, 28 per cent for France and 18 per cent for Western Germany and the United States. Moreover imports rose faster. They increased by 14 per cent.

There is no gainsaying the fact that the performance of the U.K. has not compared well with that of other European nations. Nor, it is being pointed out, has its rate of improvement of output per head of population been satisfactory by comparison with other nations over the last few years. Several reasons have been suggested. One — that those who live in this country have lost the energy and verve which made this small country for a century a world leader — we do not believe. Others are more credible. An interim report by the London Chamber of Commerce on the effects of the recent tally clerks' strike in the London docks on port users shows how serious can be the effects upon export trade of an irresponsible unofficial strike, coming on top of continuous rumblings of labour troubles and repetitive minor strikes in a major industry. Some of the reason for lack of orders in British shipyards may, no doubt, be traced to repeated "demarcation" disputes arising out of inter-union jealousies rather than dissatisfaction with pay or working conditions. Engineering shops are not wholly free from similar troubles. But it is too easy to lay all the blame on the activities of trade unions. Some of the reasons can surely be traced to lack of managerial initiative, failure properly to study prospective oversea markets, failure to provide suitable servicing facilities abroad and even failure to provide trade literature in the right language. Another reason that might be quoted for Britain's poor showing is that the rate of increase of demand in undeveloped countries may be less than in developed lands and that a high proportion of British exports go to such countries. Again, in countries recently colonial territories, but now independent, British makers may have lost competitive advantages which they once possessed. It can also be argued that Western Germany has benefited since the war from having to build up war-destroyed industries almost *de novo* with U.S. aid, and from a substantial flow of immigrants from Eastern Germany, whose coming may have helped to hold down wage demands. France recently has benefited from the effects of the devaluation of the franc. Furthermore the coming of the European Economic Community has no doubt lived up to its promise and stimulated freer trade between its members.

But, for ourselves, we come back repeatedly to the impression that economists do not understand how to regulate economies. In answer to Labour critics in Monday's debate Mr. Selwyn Lloyd had no more to offer than agreement that planning in the public sector could be improved; that there ought to be improved knowledge of what was being planned in the private sector; that "red tape" should be cut down over exporting; that "a little more money" should be available for trade fairs etc.; and that an arrangement had been made by the Bank of England to facilitate the provision of more medium term finance for exports. The evidence suggests that since the war this country has failed to plough back enough of its national product into new investment, which would have increased the national product. Why not? Perhaps because every time the trend of investment has turned upward the national economy has been held to be overstretched so that measures have been adopted which directly or indirectly have discouraged investment either by making it dearer to borrow money or by checking back the very demand the investment was intended to meet! We are not economists; we do not pretend to understand. But it does seem to us that though economists learnt from Lord Keynes how to handle a depression they still have to discover how to encourage a high rate of expansion without resorting to inflation.

EXPLOITATION OF SPACE

The announcement at the end of last week that eight large commercial companies in this country have joined together to set up a new organisation to be termed the British Space Development Company gives an answer to those, principally scientists, who argue that this country should give up attempts to build space rockets. The firms concerned are Associated Electrical Industries, Ltd., Associated Television, Ltd., British Insulated Callender's Cables, Ltd., Decca Radar, Ltd., the de Havilland Company, Ltd., Pye, Ltd., Rank Precision Industries, Ltd., and Rolls-Royce, Ltd. These firms are not merely thinking of conducting researches of the kind which British scientists can do and are to do by having satellites put in orbit by American rockets. Instead the object has been to bring together a representative cross section of that part of industry which is interested in the exploitation of space for commercial purposes. The firms concerned, presumably upon a hard-headed assessment of the situation which takes into account research and development costs, clearly believe that there are very large profits to be made from the exploitation of the commercial possibilities of space. No doubt they have observed also that the likelihood of the Americans offering the services of their rockets to set in orbit satellites intended for British commercial purposes is low. Nor does it seem likely that they would be happy about selling such rockets to Britain for such a purpose. American firms, themselves interested in the commercial possibilities of space, will, no doubt, see no

reason at all why their prospective competitors should be helped.

The aims of the new company are to include scientific research, the investigation of outer space, the propulsion and direction of vehicles, missiles and artificial satellites within the atmosphere and stratosphere, the employment of satellites in telecommunications, &c. But judging by the small capital of the new organisation — £20,000 — the initial intention is to act as a pressure group urging the Government to enter on a space programme either alone or in conjunction with the Governments of Commonwealth countries or of European nations.

TIME FOR INVENTION

Mr. H. F. Spencer, managing director of Richard Thomas and Baldwins, Ltd., speaking at the annual dinner of the Staffordshire Iron and Steel Institute recently, drew attention to the way Britain, as a nation, tends, to rely on others for her mechanical and technical developments. He was referring to the iron and steel industry, but his remarks are equally applicable to many other industries. New steel plants are being built in this country incorporating steelmaking processes such as Kaldo (Swedish), L. D. (Austrian) and Rotor (German), and continuous casting (international, though Austria and Russia did the principal development work in putting it on a commercial basis). In the building industry there are tower cranes which are British built under licence from foreign designers. In civil engineering most of the heavy earth-moving plant is of American design, though it is often built in Great Britain. Much of the agricultural machinery used here is in the same category. We could go on in the same strain. It is not necessary to look far in any branch of British industry to find a foreign design or process at work.

This inward flow of ideas is a good thing. Nobody supposes that there is a monopoly of ideas in this or any other country. But for Britain the inward flow is only good if it is balanced by an export of home-produced ideas. There is, of course, a two-way traffic in existence. Well-known examples, chosen at random, can be used to represent the export of ideas; aero engines are built abroad under licence from firms in this country, some Pametrada patents are similarly licensed to overseas manufacturers; in the field of the commercial generation of nuclear power many patents are held by organisations and firms in this country. In fact there are, we suspect, many more firms abroad paying license fees to use British inventions than home critics realise simply because it is easier to spot the foreign-licensed product in this country than to appreciate what is British licensed abroad. But still there is an inherent danger that needs watching carefully. It is tempting for a firm to look around, see an attractive foreign idea and take out a licence to use it simply because that is the easiest way out of a difficulty. Industry — especially in the export field — lives on new ideas. Old designs and processes need to be scrapped and new ones brought into use, if old customers are to be retained and new ones found. The new ideas must be the best possible ones for the job, and they do not necessarily come from any one country; but if it is to prosper an exporting country must be responsible for a proper share of them.

There is certainly sufficient scope for new ideas, in spite of the breathtaking speed at which all branches of industry have developed in the last few years. In fact, there is scope for invention *because* of the rate at which development has taken place. There is room for simplification, both of plant and processes, which will reduce the enormous capital cost of building new plant. Indeed, it is possible to foresee a position in which capital equipment becomes so costly that it could have passed its useful life and become worn out before it had returned its original costs. Ideas in this sort of field will not only pay dividends at home; they can be exported profitably. One of the dangers in using other peoples' ideas is that they will naturally have used them first, and the licensee is likely to finish up only as up-to-date as the licensor. In this competitive world it is not enough to be equal with one's competitors; it is essential to get ahead of them. One of the ways to do that is by having one's own ideas or new plant and processes. For then even if they are no better than the ideas of one's competitors they will at least be different and exhibit a different set of advantages.

HYDROLOGICAL RESEARCH

On Monday of this week Sir David Eccles, replying to a question in the House of Commons on behalf of the Minister of Science, said that a working party on hydrological research of the Department of Scientific and Industrial Research is to be "reconstituted on a wider basis as a committee on water research." The subjects to be covered include basic research into problems of conservation and long-term utilisation of water supplies. Sir David remarked that "it is generally agreed that there is a need for increased basic research into these subjects." Water engineers will regard that as a fine example of understatement.

The drought year of 1959 made it abundantly clear that the country's arrangements for conserving water are faulty. We tremble to think what would have been the outcome had it happened, as it has happened quite often in the past, that the dry summer and autumn of 1959 had been followed by a relatively dry winter and another relatively dry summer. We hope that under the expression of "long term utilisation" it will come under the cognisance of the committee that the use of water pumped directly from rivers for the irrigation of crops is rapidly increasing, especially in the eastern counties. It occurs, of course, especially in dry years just when the river flow is likely to be below normal. A recent survey of the Great Ouse showed that the normal summer flow of that river would be quite inadequate to meet the potential demand.

No doubt from the very beginning the committee will press for the more widespread and more accurate gauging of river flows. As a contributor to our pages, Mr. Newhouse, pointed out in our issue of January 20 the data at present is quite inadequate. He used the words "The meteorological and hydrographical data available in Great Britain at present bear the same proportion to what are required for flood prevention and protection, as the Armed Forces of 1914 and 1939 bore to the requirements in 1917 and 1942. Not three years but at least thirty will be required to bring the deficiencies in our hydrology up to the required standard."

ANNIVERSARY OF FRANCIS BACON

In days when the effort and expenditure lavished on technical education and research have reached unprecedented levels, there must be many engineers who will not need to be reminded of the four-hundredth anniversary of the birth, on January 22, 1561, of Francis Bacon. It was this illustrious man who, in *The New Atlantis*, described that College of the Six Days Works,

the object of which foundation was to ascertain "the knowledge of causes and secret motions of things; and the enlarging of the bounds of human empire, to the effecting of all things possible". Reading it today, we have no difficulty in recognising that in *The New Atlantis* lie ideas and suggestions which proved influential in promoting the foundation of the Royal Society. Reading the words which Bacon puts into the mouth of the Father of the College of the Six Days Works, we cannot fail to be impressed by the accent placed on research activity: "We have," he says "engine-houses where are prepared engines and instruments for all sorts of motions. There we imitate and practice to make swifter motions than any you have, either out of your muskets or any engine that you have; and to make them and multiply more easily and with small force, by wheels and other means, and to make them stronger and more violent than yours are . . . We imitate also flights of birds; we have some degrees of flying in the air. We have ships and boats for going under water and brooking of sea, also swimming-girdles and supporters. We have divers curious clocks, and other motions of return (*in orbem et vices revertentes*) and some perpetual motions . . . We have certain helps which, set to the ear, do further the hearing greatly . . . We have also a mathematical-house, where are represented all instruments, as well of geometry as astronomy".

Not without coincidental interest is the fact that the site of the house in which Bacon was born lies adjacent to the York Water Gate which, built in 1626, stands at the foot of Buckingham Street, Strand, London. Here was erected, during 1726, the first Newcomen steam engine to be installed in London, an event rendered more memorable in technical, industrial and domestic history from the circumstance that this was the first piston engine to be used for the public supply of water. We know that in the museum of inventions which was part of Bacon's College of the Six Days Works there were "the statues of all principal inventors" — including the "inventor of works in metal" —and surely it might be appropriate if, adjacent to the site of York House, some memorial were set up not only to Bacon but to Newcomen. While the lawyer will repair to Gray's Inn for monumental reminders of Lord Chancellor Bacon, the engineer would be apt to remember the author of *The New Atlantis* beside the place of his birth near the York Water Gate.

It has been remarked by Sir Sidney Lee how "All that Bacon wrote bore witness to his weighty and robust intellect, but his style was coloured not merely by intellectual strength, but by imaginative insight". Perhaps no passage from his works could better express both the power of Lord Bacon's mind and the beauty of his prose than the oft-quoted paragraph on the use of doubts: "An impatience of doubt, and an unadvised haste of assertion, without due and mature suspension of the judgment, is an error in the conduct of the understanding. For the two ways of contemplation are not unlike the two ways of action, commonly spoken of by the ancients; of which the one was a plain and smooth way in the beginning, but in the end impassible; — the other rough and troublesome in the entrance, but after a while fair and even. So it is in contemplations: if a man will begin in certainties, he shall end in doubts; but if he be content to begin with doubts and have patience a while, he shall end in certainties".

"ERGOMETRY" IN ARENA

We can imagine, and sympathise with, the probable reactions of oarsmen of the old school on reading the report that the Oxford and Cambridge boat race crews are using "ergometers" to measure the exact amount of energy that an oarsman puts into his stroke. The purist, having recovered from his initial shock, will probably decide to plunge deeper into his daily grind, in an attempt to forget, though he cannot forgive, this brutal assault by the Philistine on an arduous but pleasant sporting pastime. For our part we feel that, if rowing must be rationalised, then the engineer cannot stand aloof. But, if the art is to be reduced to a science, where will the process end? Surely it is not enough to use an ergometer to measure the effort made by the oarsman. The next step logically must be to find out the propulsive effect of the energy expended and thus to establish the overall mechanical efficiency of the system. Here is wide scope for the ardent experimentalist.

But what of other sports? Can they for long withstand the attack of applied "ergometry"? In professional football the possible benefits of hypnosis upon the players are already being explored. But is anything being done to study, for example, the mechanics of the art of kicking? Will ballistics, perhaps, become a compulsory subject to be mastered by the apprentice footballer? And in Rugger it may be worth investigating whether the set scrum is amenable to analysis as a statically indeterminate structure!

We do not for a moment question the expertise of the skilled practitioners of these sports. They have the "know-how" whether it be intuitive or acquired by hard experience. To-day, however, that is hardly enough, for competition, in sport as in other affairs, demands optimum returns from the available effort. Here, perhaps, is fresh territory awaiting exploration by applied science. Will it be long before we shall see a British university endowed with a chair of Experimental Ergometry in Athletics?

The Engineer—100 Years Ago (FEBRUARY 8, 1861)

"THE FISH-JOINT PATENT"

"On the 24th of May next the patent on the fish-joint will expire, and the invention become open to public use. We have heard it stated that Mr. William Forman of the firm of Thompson and Forman, made fish-plates in Wales twenty-five years ago, and that they were applied precisely as at present. *The Journal of the Franklin Institute* for July, 1857, states also, that a model of the fish-joint was deposited in the house of the Institute in November, 1843, and that it had then been practically applied by Mr. Robert H. Barr, a railway engineer in the United States. However this may have been, Mr. William Bridges Adams, to whom the invention has been generally attributed, was never opposed on these pretensions of priority, and it is certain that, if the fish-joint was actually in existence before his patent, Mr. Adams could have known of it only through the merest chance, and not through any publicity which it had attained.

"That he arrived at the invention by independent thought, none who know him will doubt, and it is only as the reputed offspring of his ingenuity that the fish-joint has acquired extensive introduction and commercial value. Before this value had been established however, Mr. Adams unfortunately found himself in circumstances which compelled him to part with his patent, which eventually became the property of the Permanent Way Company. Beyond the nominal consideration upon which the transfer was made, Mr. Adams has never realised a penny from the fish-joint patent."

Bridges of Historical Importance

By C. St. C. DAVISON*

IT is known that the Egyptians could construct corbelled arches as early as about 3000 B.C.; they used such arches in the pyramids of that period. But historians have not found any evidence to show that they built arch bridges. The earliest reliable evidence of bridge construction comes nearly 2000 years later, in the form of an embossed bronze band from the gates at the palace of Shalmaneser III, King of Assyria, *c.* 859 to 824 B.C. The band, which is in the British Museum, clearly shows a pontoon bridge (Fig. 1).

Fig. 1—Pontoon bridge of the ninth century B.C. depicted on an embossed band from the gates of an Assyrian palace

Evidence about early bridges is found in the works of Herodotus, the Greek historian (*c.* 484–425 B.C.)[1], Diodorus Siculus,[2] the early Sicilian historian (*c.* 60–30 B.C.) and Degrand.[3] They provide descriptions of a bridge over the Euphrates in the centre of Babylon, but the accounts vary and are based on traditional stories, distorted by time. They have, therefore, to be examined with care. But we can infer that the bridge was constructed about 700 B.C.

Piers were erected across the Euphrates with large specially-prepared, regular-shaped blocks of stone, each block being held to the adjacent one by means of an iron cramp which had each end recessed into a block and fixed there with lead. The superstructure consisted of large wooden beams stretching from pier to pier, and wooden crossbeams to support the road, about 30ft wide and three-quarters of a mile long. Herodotus said that the river had been diverted to permit the building of the piers.

In the sixth century B.C., Thales and Pythagoras, the Greek scholars, travelled widely in Assyria and Egypt, and it was from their teachings that a knowledge of geometry and arithmetic, later to become so important in bridge design, began to spread. Others, too, were observing items of importance to future bridge builders. Aristotle (born 384 B.C.) for example, spoke of keystones for arches, though there is no proof that the Greeks used them in his time.[4]

Another early pontoon bridge of note was erected at Hellespont by Xerxes, King of the Persians in 480 B.C.[5] It was a double bridge, consisting of two rows of 674 triremes (galleys with three banks of oars) and penteconters (Greek ships with fifty oars), arranged side by side across the channel, nearly seven-eighths of a mile wide, at Hellespont. Three gaps were left between the vessels for light sea-traffic. The vessels were each firmly anchored and connected together, and they supported six strong cables drawn tight by wooden capstans on the shores. Sawn planks were fastened side by side across the cables to form the superstructure, and bulwarks are believed to have been fitted on each side. Brushwood and then earth were placed on top of the planks and trodden down into a solid mass to form the road surface. The first bridge was blown away by a sudden storm before it was finished, and the overseers were beheaded for allowing this to happen. The second bridge was a success, and it withstood the passage of 10,000 Persian soldiers and thousands of men of other nationalities with horses and chariots, all on their way to punish the Greeks for assisting their Ionian friends in battle.

Among early bridges, about which little is known, is one of interesting design shown on a Greek coin of *c.* 200 B.C. (Fig. 2).[6]

Early Roman Bridges

The earliest Roman bridge on record was the Pons Sublicus (*c.* 6th century B.C.). It was a simple wooden bridge with pile-supports across the Tiber, and is the best known in history as being the bridge on which Horatius and his two fellow-soldiers held the whole Etruscan army at arm's length, while the bridge was being destroyed behind them. Piles, incidentally, were not new ; they had been used by primitive lake-dwellers to support their houses.

The Romans started to build improved stone bridges after about the middle of the second century B.C., and their achievements in this direction were remarkable. A few of them still remain, although damage caused by flood and other natural causes had to be repaired from time to time. Vitruvius (*c.* 25 B.C.), Roman architect and superintendent of machines of war, frequently referred to the Greek works which he had studied, and it is obvious from this that the Romans learned much from the Greeks. The stone bridges were built one arch at a time, with the piers strong enough to support the sideways thrusts exerted by the arch. The piers were often supported on piles, about which Vitruvius says "Alder piles driven close together support structures of enormous weight and last for a long time. If there is no solid ground-support, it must be dug up and cleared out and set with piles made of charred alder or olive-wood or oak. These must be driven down close together by machinery and the space between them filled in with charcoal. Finally the foundation stones must be placed on top in the most solid way."[7]

It has been said that in the construction (*c.* 43 B.C.) on the River Tiber of the one-arch 76ft-span Pons Cestius, later called St. Bartholomew, the piers were supported by a solid-rock bottom instead of piles.[8] We know that the Romans constructed cofferdams to enable workers to dig down below the water-level to the rock-surface. Their cofferdam had double sides composed of stakes fastened together with ties and supported by props. Clay packed into wicker baskets was tightly pressed in between the props. Then the water was pumped out by Archimedean screws and the earth removed by means of cranes, pulley-blocks and capstans. The principal stone blocks on Pons Cestius, in the arches and piers, were held together by cramps in a manner similar to that employed on the bridge at Babylon eight centuries earlier.[9] Andrea Palladio, the famous Italian architect (1518–80), described the Pons Augustus at Rimini (*c.* 20 B.C.) which was built of white Istrian stone by Augustus Caesar. He considered that the design was so good that he adopted it for the construction of his own bridges.[10]

Caesar's Rhine Bridge

Caesar's wooden trestle-bridge over the Rhine (*c.* 55 B.C.)[11] has long been a subject of controversy among engineers and architects alike. According to Caesar it was built in ten days to get his army across and punish the Germans for helping the Gauls. After eighteen days, when the army had accomplished its mission, it was dismantled. The strong force of the swiftly flowing water and also the damaging effect of tree-trunks floated down the river by the enemy were taken into consideration in the design. Caesar said that these only served to press the framework closer together. Since Italian (Palladio), French and British translators give different versions of the design of this bridge the author has devised a model (Fig. 3) showing his interpretation of it. Being on the whole a very robust bridge of its class it shows that so far as wooden bridges were concerned the Romans had much empiric knowledge. The author found by calculation that the pairs of upstream trestle-legs, which were the weakest part of the bridge, were each capable of supporting an

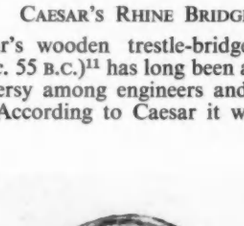

Fig. 2—Greek bridge of *c.* 200 B.C., as shown on a contemporary coin

* Dr. Davison is Assistant Keeper in charge of Roads and Bridges, Weighing and Measuring, Internal Combustion Engines Sections and Mechanical Power Transmission at the Science Museum, London.

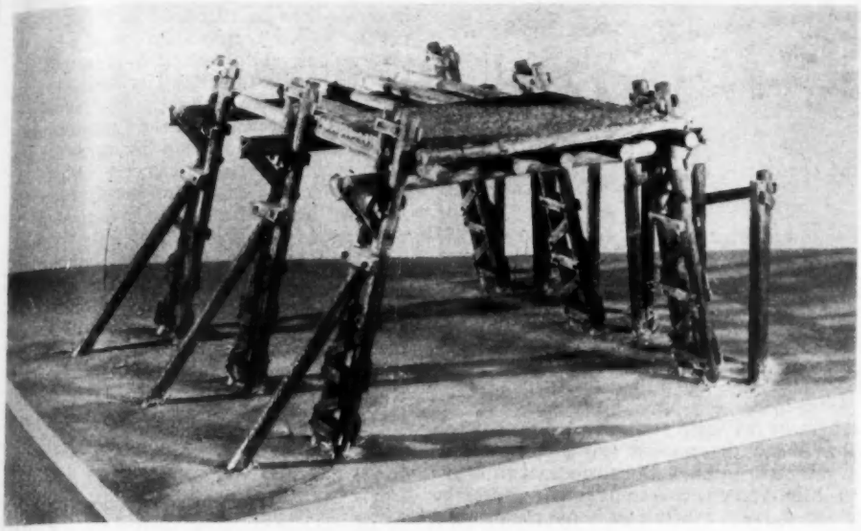

Fig. 3—Conjectural model of Caesar's Rhine bridge, *c.* 55 B.C.

horizontal force near the water level of about 15 tons in mid-river and about double that towards the banks. But there were other piles driven in in front of the legs to protect them. Each tree-trunk of the trestle-legs was about 18in diameter. The width of the roadway on top was about 20ft to 25ft.

Probably the best preserved examples of Roman bridge-building skill are the Pont du Gard in France and other aqueducts in Spain at Tarragona and Segovia. The stones of the lowest and middle tiers of the Pont du Gard were dressed and placed in position without mortar with an accuracy which must have been extremely expensive. Those in the highest tier were much smaller and were held together by cement. The water channel on top was also cemented on its bottom and sides to prevent water leakage. Considering all the forces brought into play in such structures, including the affects of storm and rain, we can still marvel at the way they were built. It should be remembered, however, that the ancients were expert stone-masons, for the 15-ton polished facing-stones of Cheops's pyramid, over 2000 years earlier, were laid together with such precision that it was difficult to pass a needle into the space along their 30ft-long joint.[12]

The cement which the Romans used in their aqueducts was one of their great discoveries, for it enabled them to construct better quays and jetties as well as buildings and bridges. At first they employed a mortar which was a wet mixture of lime and sand and it was not uncommon for their lofty apartment-houses in Rome to crumble during the night. Later they added some volcanic ash from Vesuvius to their mortar and found that it hardened even under water. It was as durable and lasting as stone.

Trajan's Bridge

The next important bridge was that of Emperor Trajan (*c.* A.D. 110). Little is known about it except what can be deduced from a relief on Trajan's column in Rome, and that both it and the column were designed by the Greek Apollodorus of Damascus. It had stone piers and a wooden superstructure of a design in some respects similar to bridges of the last century (Fig. 4). The Roman soldiers shown beside the bridge were offering their sacrifice to the river-gods to pacify their wrath for depriving them of their victims by drowning.

With the decline of the Roman Empire and the ensuing wars bridges were more of a help to the enemy than a hindrance and consequently no important ones were built for a thousand years, and it was not until the twelfth century A.D. that we find them again being constructed. The Pont St. Bénézet at Avignon, started in 1177, is such an example, and part of it still stands. In such troublesome times bridges were built with fortified towers and special entrances.

Constructional geometry of the thirteenth century is illustrated in drawings taken from a French manuscript.[13]. Fig 5 shows how the

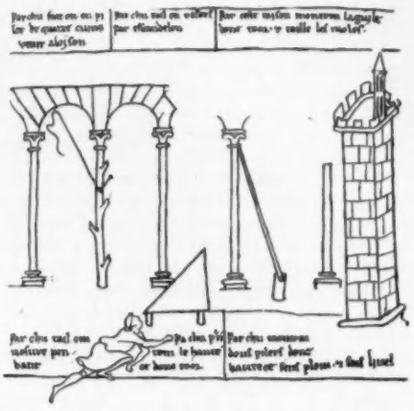

Fig. 5—Measuring and building methods in the thirteenth century

height of a tower was ascertained by the principle of proportionality of triangles, a method which was employed in Babylonia 2000 years earlier. In Fig. 6 we see a design for a cantilever bridge. An interpretation of the design was given by Viollet-le-Duc.[14] It is a link in the chain of development of truss-bridges between Trajan's bridge and that of Andrea Palladio, who is wrongly credited by some modern writers with having been the originator of the truss-bridge. Some have

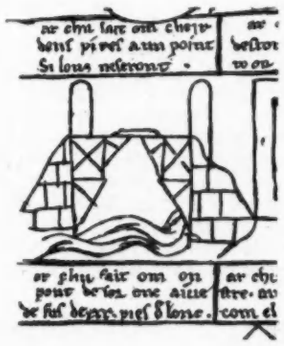

Fig. 6—Thirteenth century sketch for a cantilever bridge

claimed the honour for Leonardo da Vinci (1452–1519) as his sketches showed that he was well acquainted with truss-bridges. Palladio's drawings are remarkable.[15] One of them is reproduced in Fig. 7. At *E* there was a crossbeam and the head of an iron vertical member, flattened at the top and passing through a hole in the crossbeam. The flat upper end was bolted to the upright member *D*. Palladio explained that the great advantage of such a bridge as this one was that it required only an abutment at each end instead of a series of columns in between. There is a similarity to Trajan's bridge as shown in Fig. 4.

The covered wooden bridge, supported by rows of piles, designed by Palladio for the river at Bassano is important in that it lasted until the nineteenth century. The Swiss always excelled with such bridges, the Kapellbrucke at Lucerne, for example, having lasted from 1333 until to-day.

Although the Renaissance Period brought

Fig. 4—Trajan's bridge over the Danube, A.D. 104

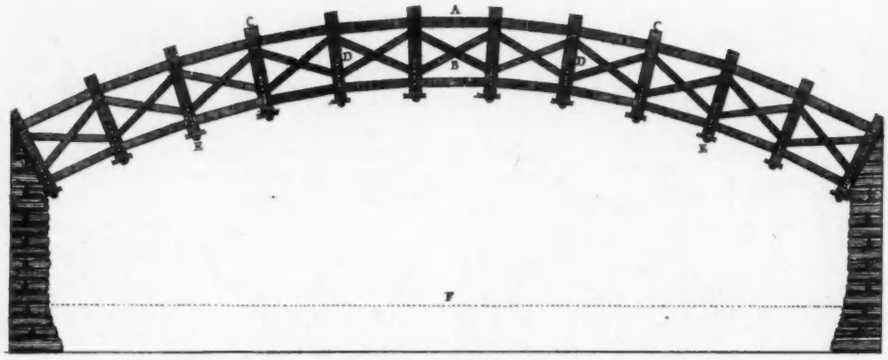

Fig. 7—Palladio's truss-bridge, *c.* 1570

more beautiful stone bridges and improved methods of building they were structurally the same as the Roman ones. From the beginning of the Renaissance Period mathematics, geometry and mechanics were increasingly applied. Although the practical builders were excellent structural designers with a highly-developed inborn sense of statics they almost entirely relied on empiric rules developed throughout the years.

Alberti gave the following rules among others in his book of 1485 : The width of the pier should be one-quarter the height of the bridge ; the width of the piling should be twice the width of the wall to be carried. In this book Alberti discussed what he had learnt from classical writers and his efforts to combine theory and practice were noticeable.[16]

Strength of Bridge-Members

The honour of introducing graphic statics where the magnitude of a force was represented on paper by means of a certain length of straight line drawn parallel to the direction of the force is accorded to Simon Stevin of Holland (1548–1620). He discovered the famous natural law which we now call the parallelogram of forces. Graphic statics supplied much more information about forces and later, in the nineteenth century, was to play an important part in structural analysis. Jordanus Nemorarius, an author of the late twelfth century (about whom very little is known) had considered problems of statics, and in so doing had consulted a few surviving manuscripts by Greek classical authors, including Euclid and Aristotle. Then in the sixteenth century Galileo Galilei (1564–1642) also became familiar with the works of the same authors. He revised and formulated the ancient learning, but combined experiments with calculations to arrive at better results. Among other things he reached useful conclusions about the bending strength of a rectangular beam. Mechanics, which had progressed very little since the time of Archimedes (third century B.C.) was consequently greatly augmented. These theoretical developments probably assisted Fausto Veranzio who, in his book of 1595, had two interesting drawings of suspension bridges.[17] The drawings were somewhat simple but at least they provided an excellent early record of this type of bridge. The first one (Fig. 8) was of a Chinese iron suspension bridge with eye-bar chains. The second one was comprised of ropes. Fa Hsien described in A.D. 400 rope suspension bridges in the Gobi and Hindu Kush.[18]

Technical Advances

The seventeenth century was a time of great scientific activity, both theoretical and practical. Scientific societies came into prominence almost simultaneously in Italy, France, England and Germany. More detailed analyses of all structural problems were carried out, which meant an even greater departure from empiric rules. The French School 'Ecole des Ponts et Chaussées,' founded in 1747, trained engineers and gained a supremacy in road- and bridge-building which it held many years. The engineers were trained to apply mathematics, geometry, and statics to determine the dimensions of structures. The results of strength-tests on various materials formed a basis for their calculations. B. F. de Belidor (1697–1761) attempted to deal with the theories of earth pressure, vaulting and bending on a mathematical basis.[19] Although his results were modest, his systematic practical approach to the subject-matter represented a great step forward towards modern engineering science. Men like Robert Hooke, Mariotte, Jakob Bernoulli, Leibnitz and others also investigated the problem of bending in materials, without, however, reaching successful conclusions. These were not arrived at until the eighteenth century when Charles August Coulomb (1736–1806) published his treatise entitled "Experiments on the Application of Rules of Maximums and Minimums to Some Problems in Statics Related to Architecture" (1773), which is considered by some as a milestone in the history of structural analysis.[20]

All this extra knowledge produced more expert engineers and in the eighteenth century, when engineers came to replace architects for great public works, we find that designs were more carefully worked out and structural dimensions were reduced without ignoring any of the general conditions for safety and durability. Most of the old empiric rules, some of which had existed from Roman times, were discarded. In the latter part of the century the type of bridge in the Renaissance style was still further modified by the introduction of new structural principles. Simultaneously, civil engineering became a distinctly specialised profession.

Stone bridges were found greatly improved, piers were smaller, and their foundations much stronger. The spans, too, were greater and their forms in general were more graceful. Wooden truss-bridges, however, still played an important part and much practical knowledge was gained from them.

The Italians and French had for long realised the advantages of employing iron instead of wood, but this was not possible because early founders were unable to cast the large pieces of metal required for bridges. The first attempt at building a cast-iron bridge was at Lyons, France, in 1755. It had to be abandoned, however, before completion as it proved too expensive and a timber bridge was supplied in its place. But the iron industry in England made great strides at that time with the result that the first cast-iron bridge was built at Coalbrookdale in 1779.[21] This bridge marked the start of a new period in bridge-building.

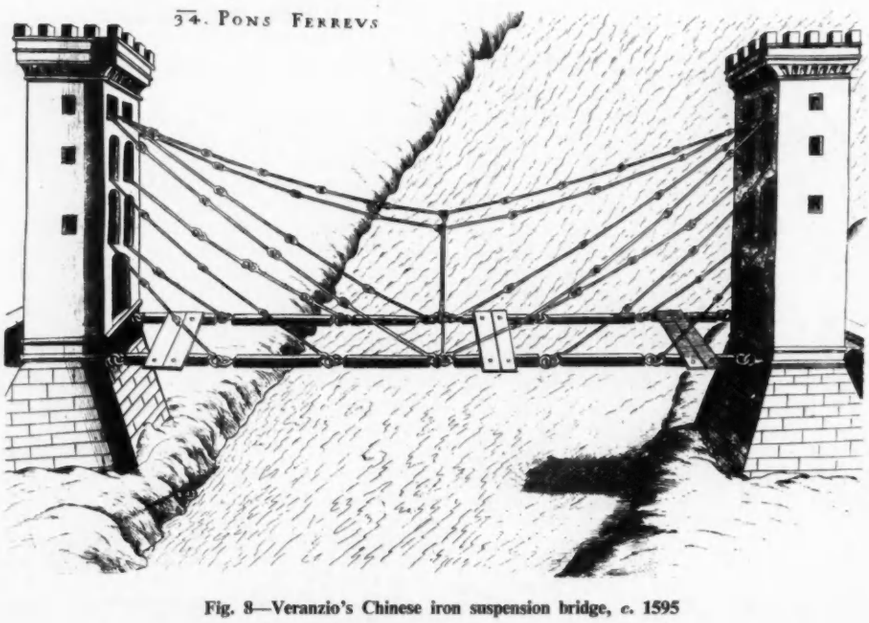

Fig. 8—Veranzio's Chinese iron suspension bridge, *c.* 1595

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Electro-Pneumatic Contactors for Traction

By H. W. LUCAS, A.M.I.E.E.*

The characteristics of the electro-pneumatic contactor have led to its being used almost exclusively in electric traction. Some of its advantages for this duty are dealt with in the following article, and probable trends of development by using new materials are outlined.

THE requirements of electric railway traction have resulted in the development of a range of specialised contactors, operated by compressed air and electrically-controlled. Characteristic features of the group are high electrical performance combined with small bulk and low weight. Within their own field of application, E.P. contactors (as they are generally called) have been developed to a high degree of reliability. Such contactors are closed by means of compressed air actuators. The actuator consists of a cylinder and piston, with the piston held against one end of the cylinder by a spring. Admitting air to the cylinder forces the piston to move up the cylinder against the spring force, and, through a mechanical connection, to close the contactor. Releasing air from the cylinder allows the spring to return the piston to its starting position, and thus to open the contactor. Admission and release of air to and from the cylinder is controlled by an electromagnetically operated valve.

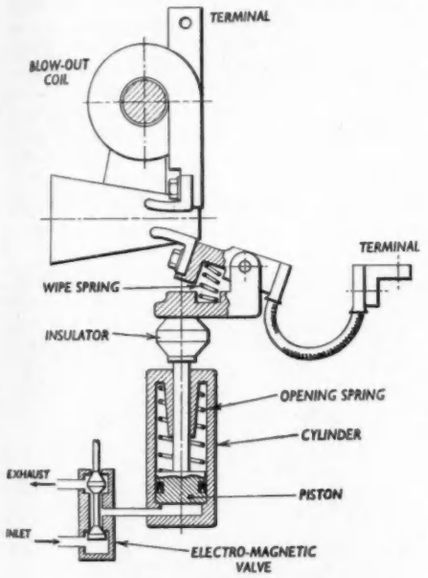

Fig. 1—Sketch showing principle of E.P. contactor

The fundamental features common to the design of all E.P. contactors are shown in Fig. 1. For many years the cylinder of the air actuator consisted of a cast-iron body carrying support brackets and lugs appropriate to the detail design, and the piston consisted of a suitably supported leather packing. Whilst these items were simple to make, they were heavy, and the leather packings required careful maintenance to prevent leaks from developing. There is a trend at present to the use of a solid-drawn aluminium tube for the cylinder, with suitable end-caps held together by draw-bolts. The piston packing is now of synthetic rubber, and normally operates leak-free for many years without attention.

The piston-rod is supported in a long bearing in the upper cylinder cap so that the current-carrying parts, which are mounted on an insulator on top of the piston-rod, need no additional support. In the largest types of contactor the current-carrying parts tend to become too heavy for this form of construction. They are then provided with some form of hinged support arm which is connected to the piston-rod by links (which are often of insulating material).

When the current-carrying parts are entirely supported on the piston-rod, the detail design is such that the point of final electrical contact is on the centre line of the cylinder. In this way, high contact pressures can be used, with a minimum of mechanical stress in the current-carrying parts.

The moving contact is arranged to have wiping action, in the usual way, but it should be noted that the wipe spring makes no contribution to the contact pressure when the contactor is fully closed. This allows the spring design to be governed to a great extent by the requirement that contact closure shall be virtually free from bounce. The contactor is opened, and held open, by the spring within the cylinder.

The electromagnetically-operated air valve which controls the air supply to the contactor is a standard component, with fixed port sizes, but the passages in the contactor cylinder are peculiar to the contactor concerned, and may be used as a means of varying the rate of admission and release of air to the cylinder. Changes in the dimensions of the passages leading to the cylinder may lead to variations in speed during the closing action. For example, the contact

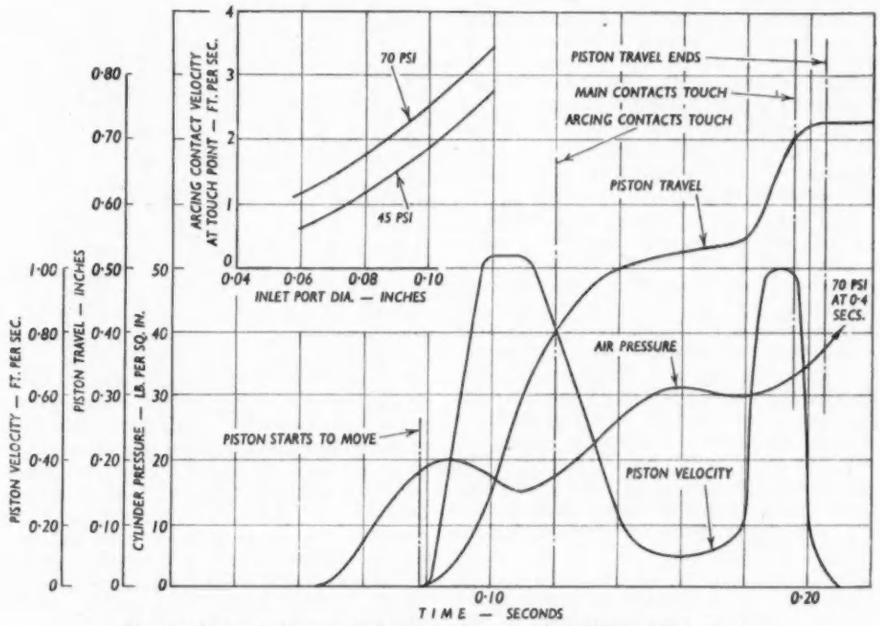

Fig. 2—Curves showing mechanical behaviour of typical 3500A, E.P. contactor

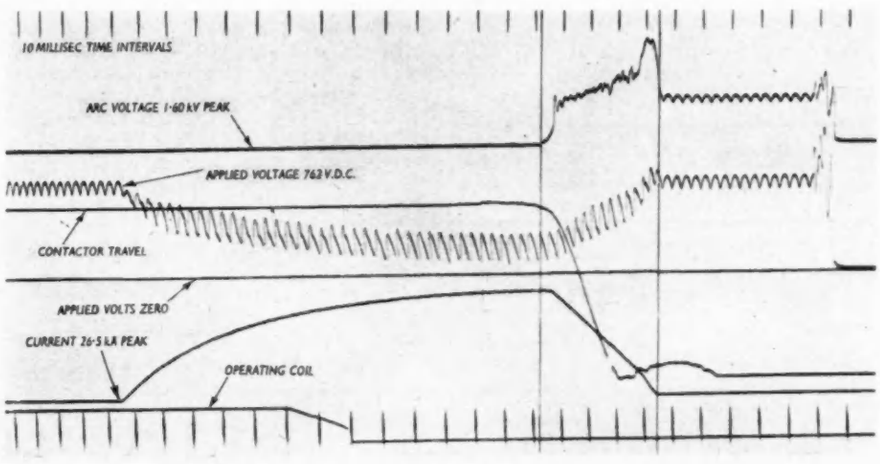

Fig. 3(a)—Fault rupturing performance of a typical 3500A, 750V, d.c. contactor. Declared rupturing capacity 20kA at 750V d.c.

*The English Electric Company, Ltd.

speed may be reduced at the instant when the contact tips meet because the rising air pressure within the cylinder needs time to reach equilibrium with the contact pressure which has suddenly been added to the other forces acting. Such a hesitation can affect the performance of the contactor if it is called upon to close on heavy faults, but careful design can render these effects unimportant. However, they can never be entirely neglected. The performance of a typical contactor is illustrated in Fig. 2.

From the brief description of the design it will be appreciated that certain basic differences exist between E.P. contactors and other forms. Furthermore, certain properties are inherent in the design which are not available, or are difficult to achieve, in other designs. Generally speaking, E.P. contactors have continuous ratings above 300A. Ratings in the range 500A to 1000A are most common, but contactors are now being built with ratings up to 3500A.

Electro-pneumatic contactors are usually operated by compressed-air at 70 p.s.i. because this matches the compressed air supply available for the air brakes on electric locomotives. At this pressure high contact pressures are possible with cylinders of moderate dimensions, and contact pressures of 150 lb are commonly used. The easy control of operating speed has already been mentioned, and these operating speeds can be, and usually are, higher than is possible with a corresponding electromagnetically-operated contactor. For example, a typical 900A contactor will be fully closed seventy to eighty milliseconds after energising the control valve and the contacts will part about forty milliseconds after de-energising the valve.

It is worth noting that there is a blast of air from the exhaust each time the contactor opens. It is usually possible, and often considered worthwhile, to direct this air into the rear of the arc-chute and use it to assist arc-rupture. On heavy faults the air does little more than " scavenge " the arc-chute of residual gases, but at low currents it offers decided advantages. It is well known that the breaking of low currents on highly inductive circuits can present a problem on a contactor with electromagnetic blow-out only. The addition of a moderate air blast to augment the electromagnetic blow-out will usually overcome this problem, and this is easily done on an E.P. contactor.

As the contactor air system is leak-free, no air is used in keeping the contactor closed. Furthermore, the power required by the magnet valve is small (about 12W to 15W) and is independent of the size of the contactor. This is often an advantage where a large number of contactors are to be operated from an electrical supply of limited capacity, such as a storage battery.

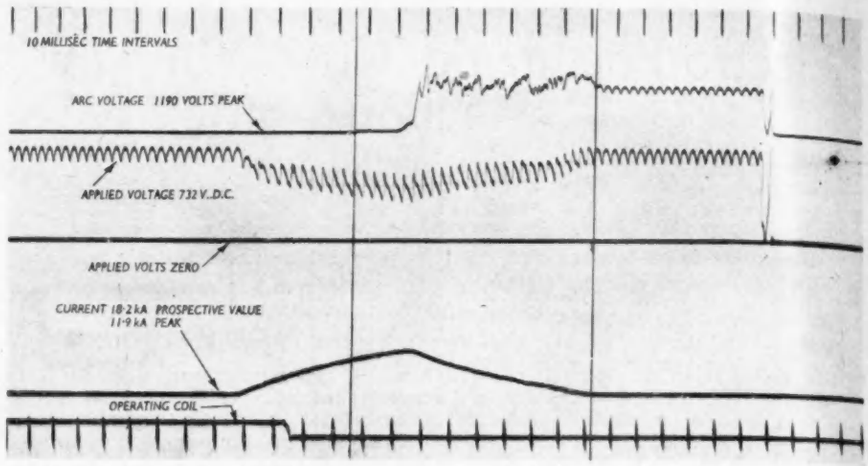

Fig. 3(c)—Fault rupturing performance of a typical 900A, 750V, d.c. contactor. Declared rupturing capacity 10kA at 750V d.c.

Because E.P. contactors have been developed for a specialised duty, it is usual for a typical range to have identical fixing centres. For example, contactors intended primarily for mounting in under-car cases on motor-coach stock would all have fixing centres to suit. Furthermore, the contactors are usually installed in severely restricted enclosures so that the arc products must be retained within the arc-chute to a greater extent than on many purely industrial designs.

When an E.P. contactor is required to have the maximum possible rupturing capacity, as when acting as a line breaker on a large locomotive, certain variations of the basic design can be used with advantage. For example, an additional exhaust valve can be and sometimes is, fitted. This is arranged to open under special circumstances only, but when it does the contactor will open much more quickly than normal. How much more quickly depends on the size of the additional exhaust port provided. Furthermore, it is possible to fit an overload trip on the contactor itself. This overload trip is arranged to open an exhaust valve direct and thereby reduce the time delay on opening due to the operation of the magnetically-operated valve and, possibly, associated relays. Such devices are capable of giving a time of fifteen milliseconds from detection of a fault to the point where the contacts part.

Fig. 3 shows oscillograph records of some typical ruptures, and Fig. 4 illustrates typical contactors.

Electro-pneumatic contactors are used almost exclusively in electric traction, and in this field find application over a wide range of duties. They are widely used as setting-up switches and resistance contactors in the power circuits of electric motor-coaches and locomotives. This application usually calls for complicated interlocking between contactors because the circuit controls are often automatic. To meet this requirement the

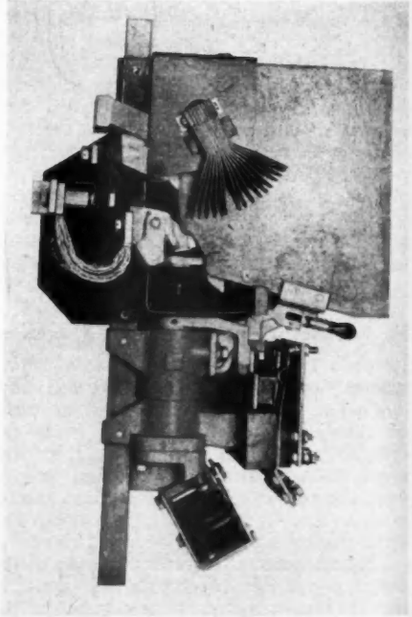

Fig. 4(a)—750A, 50 c/s, a.c. contactor complete with interlock contact assembly. By changing the blow-out pole pieces only, this contactor becomes suitable for 900A d.c.

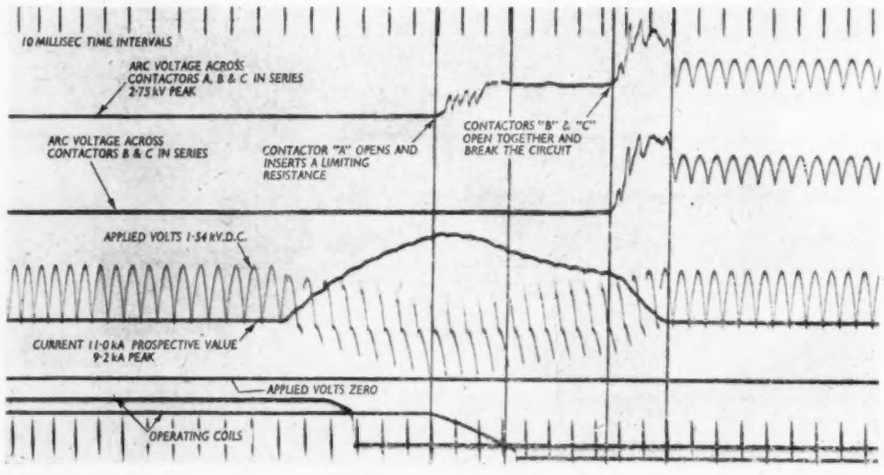
10 MILLISEC TIME INTERVALS
ARC VOLTAGE ACROSS CONTACTORS A, B & C IN SERIES 2·75 kV PEAK
ARC VOLTAGE ACROSS CONTACTORS B & C IN SERIES
CONTACTOR "A" OPENS AND INSERTS A LIMITING RESISTANCE
CONTACTORS "B" & "C" OPEN TOGETHER AND BREAK THE CIRCUIT
APPLIED VOLTS 1·54 kV.D.C.
CURRENT 11·0 kA PROSPECTIVE VALUE 9·2 kA PEAK
APPLIED VOLTS ZERO
OPERATING COILS

Fig. 3(b)—Fault rupturing performance of three typical 600A contactors operating as a group at 1500V, d.c.

contactors are usually made so that any number of auxiliary contacts, up to a total of six, can be fitted. Furthermore, and this is often important, the auxiliary contacts can usually be of a " timed " variety, i.e. they can

operate before, after, or at the same time as the main contacts.

Fitted with more elaborate arc-chutes, E.P. contactors are used as line breakers, and designs exist for voltages up to 3kV d.c. With

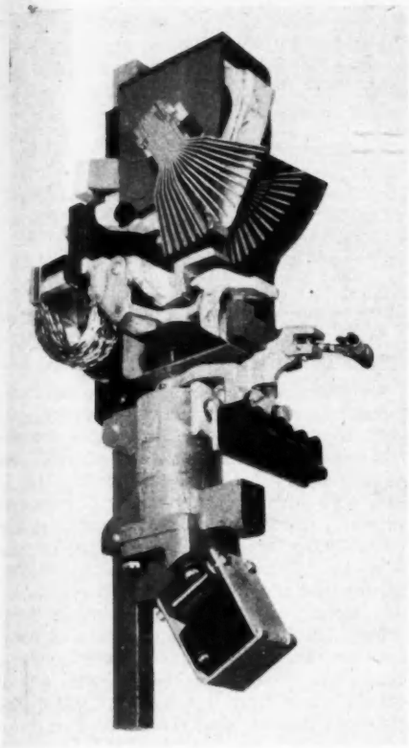

Fig. 4(*b*)—Contactor shown in Fig. 4(*a*) with arc-chute removed to expose main contacts, and with auxiliary contacts removed to show "timed" cams

these special arc-chutes rupturing performance is high. For example, a typical 900A design will clear 10,000A at 750V, and a typical 3500A design will clear 20,000A. Of course, any statement of rupturing capacity on d.c. has little meaning unless the time constant of the fault circuit is given. The above

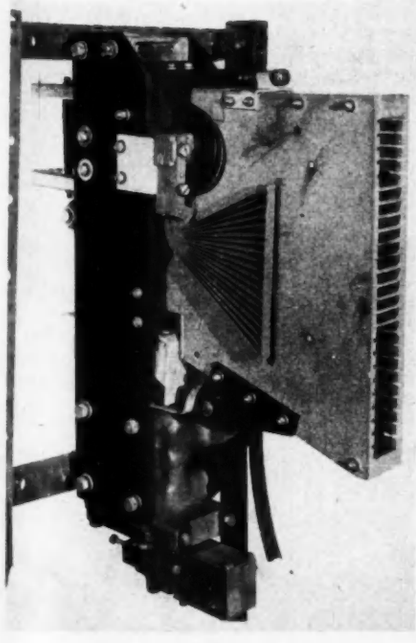

Fig. 4(*c*)—Typical 1500A, 50 c/s, a.c. contactor

figures are with a time constant of 0·03 seconds. On faults of less inductance somewhat higher currents can be cleared successfully.

Electric traction requirements demand extreme reliability, and a long history of development has made the E.P. contactor outstanding in this respect. The life of a typical contactor may be expected to exceed 2×10^6 operations without attention other than to the contacts, and 5×10^6 operations without any major replacements, other than contacts.

Future trends in the development of the E.P. contactor may be summarised under three headings: (1) a reduction in size and weight for a given rating (or an increase in rating for the same size); (2) a reduction in the amount of maintenance required; and (3) an improvement in the rupturing capacity.

Reduction in size and weight may well be achieved by more economical use of conducting materials and an increase in the use of light alloys, and possibly reinforced plastics, for structural components. As an example of what has already been achieved, a modern 1000A contactor weighs 34 lb, which is

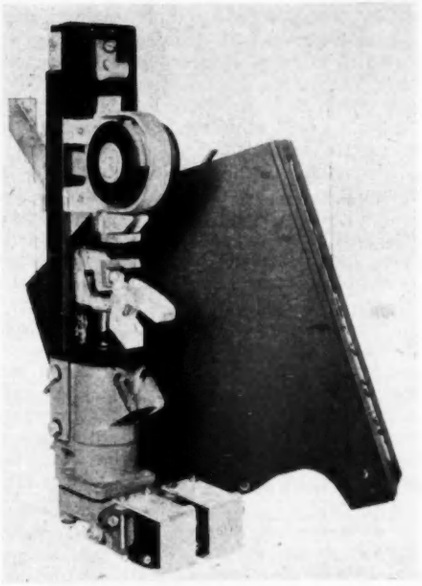

Fig. 4(*d*)—Typical 1500V, d.c. contactor, capable of carrying 600A. The blow-out pole pieces are attached to the arc-chute which has been removed to expose the main contacts and to illustrate the easy access

rather less than the 300A contactor of twenty years ago from which it has been directly developed. A great deal has already been achieved in the reduction of maintenance, but the advent of dry lubricants and low-friction synthetic materials opens up further fields of inquiry.

The duty of an E.P. contactor in traction service calls for it to open frequently on currents at or near the full-load rating, and to operate occasionally on currents which approach the limit of performance. Coupled with this is the need for maximum contact life and the need to operate for long periods with no attention. The use of new arc-chute materials and the development of improved arc-chutes will lead to better performance under these conditions.

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ACKNOWLEDGMENT

The author wishes to thank the English Electric Company, Ltd., for permitting publication of this article.

Technical Reports

Survey on Nickel and Chromium Recovery in the Electroplating Industry. By E. P. Harris, D.S.I.R. Report. Free on application to D.S.I.R., 5-11, Regent Street, S.W.1.—Wastage of nickel and chromium salts in the electroplating industry is not only substantial but often causes a pollution problem to both the electroplater and the drainage authority. The results of a survey by the Department of Scientific and Industrial Research, in co-operation with the British Non-Ferrous Metals Research Association and the electroplating industry, are published in this report. In the survey promising lines of attack for the elimination of waste and the reduction of pollution are discussed.

It is pointed out that nickel and chromium salts are largely wasted by "drag-out"—when the solution is carried away by plated articles as they leave the plating bath—although spray formation is often a cause. Out of an estimated total weight of 2870 tons of nickel used by the plating industry in 1958, about 290 tons represented the metal content of the nickel sulphate and chloride used. These chemicals increase the total material cost by about 13 per cent, but the use of a simple static rinse tank has been found to eliminate three-quarters of the cost of these added salts. Installation of such a tank in a manually-operated plant is usually inexpensive and the outlay may be recovered within one year. Reduction in water consumption by use of counterflow rinses is also recommended.

The author of the survey further concludes that there is great potential value in the ion-exchange process for the purification and re-use of effluent solutions. At present this process is handicapped by the initial cost of equipment and lack of operating experience. It is, however, a promising alternative to present effluent treatment by chemical means, which reduces impurities to a valueless sludge.

Studies on Bridge Deck Systems. II: Bending Moments in a Plate-and-Girder System. National Building Studies Research Paper No. 31. H.M. Stationery Office. Price 4s.—This is the second in the group of the Building Research Station's research papers having the general title "Studies on bridge-deck systems," of which the first was "Tests on a model jack-arch slab." It presents a theoretical analysis of the behaviour of a plate-and-girder system, employing certain simplifying assumptions that enable the parameters to be reduced to two: the ratio of the stiffnesses of the girder and the plate, and the ratio of the girder spacing to the span of the bridge. The method of analysis was designed to take advantage of the computing power of high-speed digital equipment; National Physical Laboratory staff programmed the computation for A.C.E. and other computing equipment, and produced the tables from which the diagrams have been compiled.

The first case examined is the infinite system where the plate is supported by an infinite number of identical, parallel girders at right-angles to the abutments. The next system dealt with is the semi-infinite case with a girder supporting an otherwise free edge of the plate. For a point load the solution for this system approaches that for the infinite case as the loading point moves away from the edge. The changes in the bending moment from the infinite to the semi-infinite case are due to the presence of the edge, and may be computed. In the same way it is possible to make allowance for a second edge, and hence with a finite system. The minimum width/span ratio of the finite bridge depends on what errors are acceptable in the bending moments in the end girder. The results of this investigation amounted to far more than could reasonably be printed, and in the report they are set out in a series of families of curves which give only the bending moments along the mid-span line of the bridge.

Application of Water to Machine Undercutting and to Deep Hole, Extra High Pressure Infusion in Coal Seams. Instructional Pamphlet No. 3. By the North Western Divisional Committee on Dust Prevention and Suppression. London: H.M. Stationery Office. Price 1s. 6d.—This pamphlet, prepared as a guide for colliery officials and workers, deals in detail with deep hole infusion by which water is injected deeply into seams in sufficient quantity to dampen the coal thoroughly before extraction and thereby reduce liberation of dust during working. It has been found that the system gives little risk of deterioration of the average floor or roof when used and it is considered that regular adjustments during routine deep hole infusion should ultimately evolve a method whereby the coal is effectively wetted to limit the production of airborne dust. Experience has shown that where high-pressure pumps are used for infusion the whole operation on a face of normal length can be carried out in a single shift and provide sufficient treatment for a full working week.

Steel in India

By M. D. J. BRISBY* and J. DOBIE*

India's three large new steel works are nearing completion and in a few months' time steelmaking capacity in the sub-continent will be 6,000,000 ingot tons a year. This will represent more than a two-fold increase in the last ten years. Some feel that it is time for consolidation and that India should concentrate on getting the most out of the capacity she now has, and slow down the pace of capital expenditure. Others have different and more ambitious ideas. If these are measured to India's financial resources they seem extravagant but if measured to the country's needs, the additional capacity proposed under the Third Five-Year Plan will still leave India with a steel consumption per head below the "poverty line."

STEEL is now widely accepted as a measure of a country's wealth and of the standard of living enjoyed by its people. Vast quantities of steel are required to build up a country's transport services, to construct the factories which will manufacture the plant and equipment to fabricate the capital investment goods essential to the national economy ; these capital investment schemes will, in turn, produce the consumer goods which directly affect the life of the people.

The World's main steel producers are shown in Table I. The figures given are those for 1957 (1958 tonnages were abnormally low due to the recession and 1959 figures are not yet confirmed).

TABLE I—*The World's Main Steel Producers*—1957 *Production in Million Tons.*

Europe*	104·27	Canada	4·53
U.S.A.	100·64	S. Africa	1·65
Russia	50·24	India	1·71
Japan	12·37	Brazil	1·28
China	5·17	Mexico	0·58

* E.C.S.C., 55·45 ; Great Britain, 21·70 ; Eastern Europe, 11·70 ; Others, 15·42.

It will be seen that Europe, the U.S.A. and the U.S.S.R. are together responsible for 255 million ingot tons of steel or about 90 per cent of world production. The real measure, however, of a country's economic wealth, is its apparent consumption of steel per head of population. Table II shows the pattern of consumption of steel per head in the main steel producing countries of the world. Once again, the figures are those for 1957. The U.S.A. and Canada top the list with a steel consumption per head of 1244 and 930 lb respectively. Next come the European countries Sweden, Germany, the U.K. and Czechoslovakia with consumptions upwards of 790 lb per head. The under-industrialised communities of the world, notably India, Ceylon and Pakistan are considerably further down the scale.

TABLE II—*Steel Consumption in Ingot lb Per Head of Population*, 1957.

Argentine	156	France	495	Pakistan	8
Australia	635	W. Germany	896	Poland	382
Austria	459	Greece	75	Portugal	92
Belgium-Lux.	659	Hungary	338	Spain	122
Brazil	60	India	22	Sweden	927
Canada	930	Eire	77	Switzerland	532
Ceylon	11	Italy	307	Turkey	26
Chile	142	Japan	317	S. Africa	333
Czechoslovakia	790	Mexico	83	U.K.	828
Denmark	453	Netherlands	596	U.S.A.	1244
Rhod-Nyasa	71	New Zealand	406	U.S.S.R.	543
Finland	464	Norway	585	Venezuela	663

World consumption of steel has grown by about 30 lb per head between 1937 and 1950 and by a further 50 lb between 1950 and 1957. It is still only about 210 lb per head of population or about 40 per cent of the steel consumption in Switzerland, France and the U.S.S.R. Much is being done to remedy the situation, particularly in the under-industrialised countries, but much more will have to be done if the growth of steel is to keep pace with the growth in population. The average American is surrounded by about 9 tons of steel. It has been suggested that a minimum of 2 tons of steel per head of population represents the primary requirement for a tolerable living standard for food, shelter, transportation and personal welfare.† An under-developed country starting with virtually no steel industry would therefore have to produce steel at the rate of 300 lb per head of population for fifteen years before it would achieve a minimum standard of material well-being.

The problem of population, while not peculiar to India, is a major factor in the realisation of development programmes. Improvements in sanitation and medical care have brought about a significant reduction in India's death rate. During the period 1947–57 the death rate fell from 19·7 per thousand to 11·4. An equally impressive decline in infant mortality has been achieved in this period—a reduction from 146 per thousand to 100 and a current birth rate in the region of twenty-six per 1000 poses very real problems. Effective birth control is a complete, if theoretical, solution and the application of oral contraception may ultimately overcome the difficulties now being experienced by the Indian Government in educating the not over-literate population in the use of available methods. Meanwhile, the problem is serious and may well restrict the progress of the current Plan. By 1971 India's population will be in excess of 500 millions. According to the draft outline of the Third Five-Year Plan the pattern of increase will be as shown in Table III—the figures are revised estimates made by the Indian Central Statistical Organisation.

† Harrison Brown, Bonner and Weir, *The Next 100 Years*, Viking Press, New York, 1957.

TABLE III.

Year	India's population (estimated) million	Increase millions
1960	420	—
1961	431*	11
1965	480	49
1971	528	48
1976	568	40

* This estimate is 23,000,000 higher than an earlier estimate for the same year.

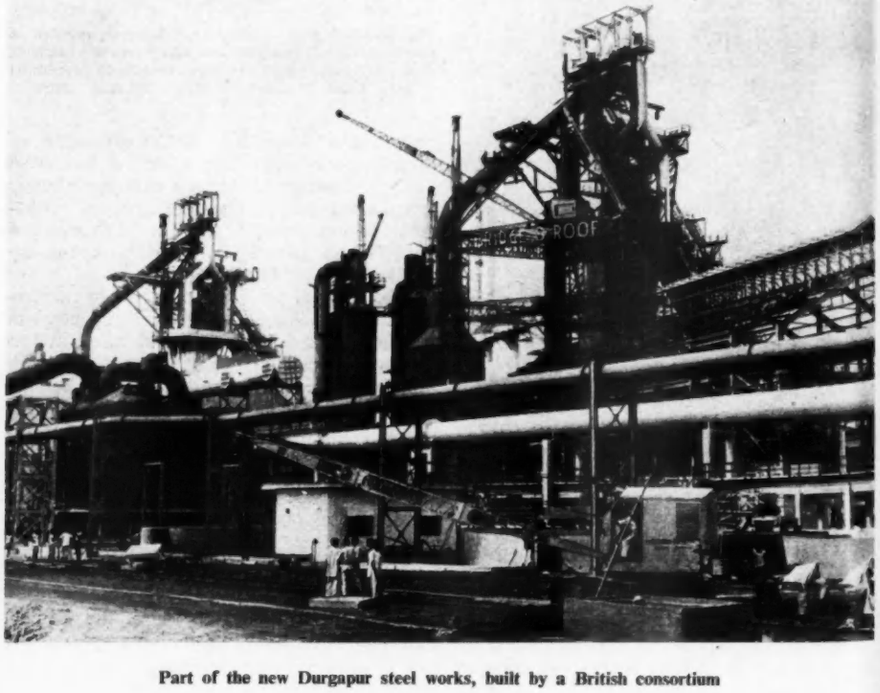
BACKGROUND TO EXPANSION

An international team of consultants was commissioned by the Indian Government in 1949 to submit outline proposals for the expansion of the existing steel industry. No positive action followed this survey and in 1952–53 a further, more objective "ways and means" investigation was conducted by World Bank representatives in conjunction with the Indian Iron and Steel Controller. At this time most of India's steel production was carried out by two large private companies, The Indian Iron and Steel Company, Ltd., and The Tata Iron and Steel Company, Ltd. The balance of the national annual output came from the Government-owned Mysore Iron and Steel Works.

As a direct result of the 1952–53 survey, plans were evolved by all three producers to increase their capacities as follows :—

	1952-53 ingot tons	1960-61 ingot tons
Indian Iron and Steel	500,000	1,000,000
Tata Iron and Steel	900,000	2,000,000
Mysore Iron and Steel Works	36,000	100,000
Three Government plants	—	3,000,000

These plans are now approaching completion. The outputs of these plants plus those of the three new integrated works now nearing



Part of the new Durgapur steel works, built by a British consortium

* W. S. Atkins and Partners, London.

completion will be in excess of 6,000,000 ingot tons a year. The next phase is critical. Further major expansion is necessary and while this, as a premise, is not in dispute, the diversity of opinion on the form this expansion will take will have to be resolved as soon as possible.

The translation of India's economy from agriculture to industry will be a gradual process. Since their inception, the Five-Year Plans have laid considerable emphasis on agricultural development and while there are indications of an increase in the relative importance of industry, agriculture will continue to form the basis of the country's economy for some time to come. In Table IV a comparison is drawn between the relative appropriations in the public sector under the Second and Third Plans for the various fields of development.

TABLE IV.

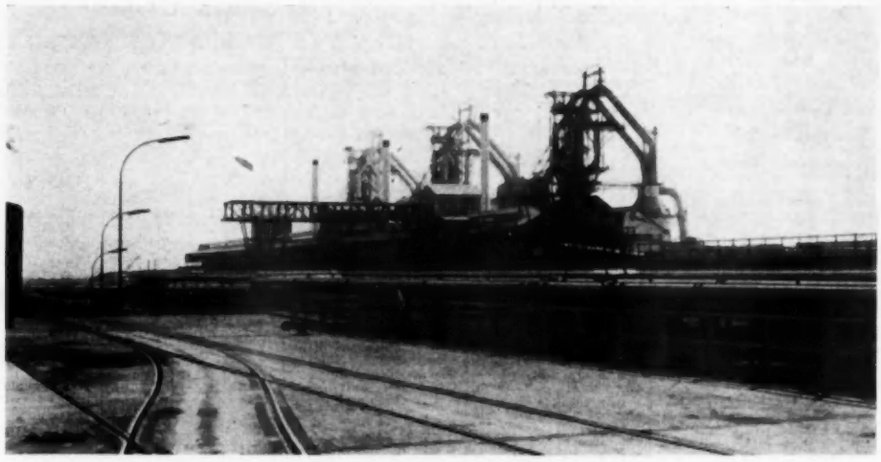
	Second Plan		Third Plan	
	Outlay, rupees crores	Per cent	Outlay, rupees crores	Per cent
Agriculture and minor irrigation	320	6·9	625	8·6
Community development and co-operation	210	4·6	400	5·5
Major and medium irrigation	450	9·8	650	9·0
Power	410	8·9	925	12·8
Village and small industries	180	3·9	250	3·4
Industry and minerals	880	19·1	1500	20·7
Transport and communications	1290	28·1	1450	20·0
Social services	860	18·7	1250	17·2
Inventories	—	—	200	2·8
Totals	4600	100	7250	100

Final detailed planning for the Third Five-Year Plan is approaching completion at a time when India's foreign exchange problems are serious. The Second Plan, which concludes in March, 1961, is likely to leave an unexpected foreign exchange deficit of some £100 million. In addition, there is the anticipated deficit during 1961–66 to be considered. Estimates of this are in the region of £1800 million. These problems are currently under discussion in most of the World's financial centres and considerable progress has been made towards their resolution.

Ironically, the attitude of the West is quite likely to have been tempered by the nature of recent world events such as the decline in Indo-Chinese relations and the Summit failure. Such trends may well have induced in the West an acute awareness of an ever-increasing need to furnish economic aid to India. India's ability to service loans during 1961–66 is not considered to be very extensive and this, coupled with the overhang from the Second Plan, creates perhaps a not too favourable climate for the Third Plan to be born into.

Substantial cuts-back of imports are probable unless a high percentage of the deficit is underwritten by the West. The extent to which this problem has been faced (and provisionally resolved) is as follows: The £100 million deficit from the Second Plan has already been partly negotiated and international finance is provisionally available from Canada (£3,500,000), World Bank (£18,000,000), Germany (£11,000,000), and U.S.A. (£11,000,000). Of the £55,000,000 outstanding, it is possible that a further £35,000,000 will be forthcoming following talks recently held in W. Germany where the Indian Finance Minister discussed a £11,000,000 loan and the postponement of an £8,000,000 repayment on the Rourkela steel works.

Whether or not the whole of the aid promised will, in fact, materialise is open to some doubt and further discussions on the subject have taken place since the 1958 and 1959 meetings. The Five-Power Paris meeting last September between the U.K., U.S.A., Canada, W. Germany and Japan was described as a preliminary examination of the problem, suggesting that the then existing promises were, to say the least, tentative. Supposing the necessary finance to be available (including the recently announced U.K. loan of £5,000,000) the close of the Second Plan and the advent of the Third will be in a "fairly solvent" atmosphere with, according to the latest assessment, £56·25 million in foreign aid available towards financing the first stages of the Third Plan. The Washington meeting in March, 1961, between the main creditor nations will do much to clarify the situation and a clearer picture of the true financial outlook will, for the first time, be possible.



The new steel works at Rourkela is German built

Considerable financial assistance has already been given to India in connection with the three new steelworks. The amounts and terms of payment for the credits are outlined in Table V.

A long standing feature of India's economic policy has been a firm insistence that all basic industrial expansion, particularly in iron and steel, should take place in the public sector. This view has not found favour with U.S. steelmaking interests who have for some time been discussing the proposed fourth new plant at Bokaro. It seems likely that a compromise arrangement will be reached under which the equity capital would be equally divided between the American investors and the Indian private sector. Further difficulties can be anticipated regarding staffing as it is unlikely that the U.S. interests will concede anything approaching full Indian administration and management—at least for a number of years.

THE FUTURE

The steel industry has, even now, built-in facilities for expansion—Rourkela can be increased in capacity from 1,000,000 tons to 1·5 million tons and both Bhilai and Durgapur can be raised from 1,000,000 tons to 1·3 million. In the case of Bhilai, a second expansion phase is possible up to a maximum of 2·5 million tons a year. These not inconsiderable increases can all be achieved at relatively low cost, having been envisaged and provided for in the original conceptions.

In May, 1960, the Indian Planning Commission published a provisional breakdown of the steel programme to be carried out during the 1961–66 period. The target figure of 9·3 million tons was allocated as follows:

	Million tons		Million tons
Bhilai	2·1	Burnpur	1·0
Jamshedpur	2·0	Bokaro	0·5
Rourkela	1·8	Bhatravati	0·1
Durgapur	1·6	Small furnaces	0·2

Further revisions to these proposals have since been made in the recently published draft of the Third Plan. The draft includes a revised target of 10·2 million tons of ingot steel and 1·5 million tons of pig iron.

A steel target 900,000 tons greater than that published last year may be thought to be optimistic. The probability of achieving this is not increased if the steelmaking performance during the Second Plan period is examined. With only a few months left until the end of the period (1956–61) it is estimated that total finished steel products will be about 2·6 million tons. Although Durgapur, Bhilai and Rourkela were by no means fully operational during the period this is not entirely valid as a defence as there was a total capacity installed of some 4·5 million ingot tons. The nature of the industry's future expansion and the range of products to be made available is shown in Table VI.

RAW MATERIALS

India's natural wealth of iron ore is not, unfortunately, matched by good supplies of coking coal. Similarly, indigenous dolomite and limestone are not always readily available in good qualities. The main iron

TABLE V.

Project	Amount	Source	Terms†
Durgapur	£15,000,000	U.K. Government	Four payments of £3·75 million at current borrowing rate (U.K.) + 1 per cent
	£11·5 million	British Banks Syndicate*	Five equal payments within two-and-a-half years at current borrowing rate (U.K.) + 1 per cent but not less than 4½ per cent. First payment due January 1, 1962.
Rourkela	£57,000,000	West Germany	Repayable over three years at 6 per cent. Interim payment currently deferred until 1961 and liable to further postponement.
Bhilai	£42·5 million	U.S.S.R.	Twelve equal payments at 2½ per cent. Repayment is currently scheduled during 1971.

* Lloyds–Martins–Glyn Mills–District and Barclays Banks and Lazards.
† Where applicable repayment dates are operative from commencement of production.

TABLE VI—*Indian Steel Plants.*
Plant Facilities and Products Breakdown

	Tata Iron and Steel Company, Ltd.	Indian Iron and Steel Company	Mysore Iron and Steel Company, Bhadravati	Rourkela	Bhilai	Durgapur
Number of blast-furnaces	six	four	One charcoal and coke Two elec. furnaces (One 80 tons Two 100 tons)	Three	Three	Three
Capacity, tons per day	650 to 1,650	800 to 1,250		1,000	1,135	1,250
Pig iron, tons per year	1,911,000	1,000,000	80,000	945,000	1,110,000	1,200,000
Pig iron for steelmaking, tons per year	1,761,000	800,000	60,000	945,000	775,000	900,000
Pig iron for sale, tons per year	150,000	200,000	20,000	50,000	335,000	300,000
Steelmaking, tons per year	No. 2 Duplex 720,000 No. 3 O.H. 1,142,000 No. 1 O.H. 120,000 Elec. furn. 18,000 2,000,000	Duplex and O.H. 1,000,000	Two O.H. furnace (will be increase to three)	LD Process 750,000 O.H. Basic 250,000 1,000,000	Basic O.H. 1,000,000	Basic O.H. 1,000,000
Mills	Two blooming mills Two cont. billet mills One skelp mill (12in) One plate mill One merchant mill One medium and light structural mill One sheet mill (with galvanising pot) One heavy structural mill (28in) One sleeper plant (pressed sleepers) One wheel, tyre and axle plant	One blooming mill One cont. billet mill One heavy structural mill (34in) One medium and light structural mill (18in) One merchant mill One sheet mill (with galvanising pot)	One 20in mill (one stand) One 16in mill One hoop mill	One blooming and slabbing mill One heavy plate mill (110in) One cont. strip mill (66in) One cold rolling mill (60in) One tinplate mill (hot dip)	One blooming mill One rail and struc. mill One cont. billet mill One light struc. mill	One blooming mill One intermediate mill One medium struc. mill One merchant mill One cont. billet mill One wheel, tyre and axle plant
Products, tons :						
Plates, ⅛in and over	100,000			220,000		
Sheets black (incl. gal. pot)	150,000	120,000				
Sheets and strips (hot rolled)				300,000		
Sheets and strips (cold rolled)				170,000		
Tin plate (hot dip)				50,000		
Heavy rails, structural, sleepers, &c.	250,000	250,000			365,000	60,000*
Merchant sections, medium structurals and bars	542,000	260,000	80,000			
Medium and light structurals					265,000	450,000
Wheels, tyres and axles	30,000					40,000
Skelp and strip	150,000					
Sleeper bar	6,000					
Hoops and rods			20,000			
Billets for sale	250,000	140,000			140,000	140,000
Forging blooms and billets	22,000	10,000				100,000
Saleable steel production	1,500,000	800,000	100,000	720,000	770,000	790,000

Note : Tonnage all in long tons of 2,240 lb. *60,000 tons sleeper bar

Reproduced from *History of Expansion of Steel Industry in India*, by R. N. Dutt, one-time deputy Iron and Steel Controller, Government of India.

ore deposits are located in the states of Bihar, Orissa and Madhya Pradesh where some 15,000 million tons are available—this material has an iron content of between 55 and 68 per cent. Total known reserves are distributed as shown in Table VII.

TABLE VII—*Indian Iron Ore Reserves.*

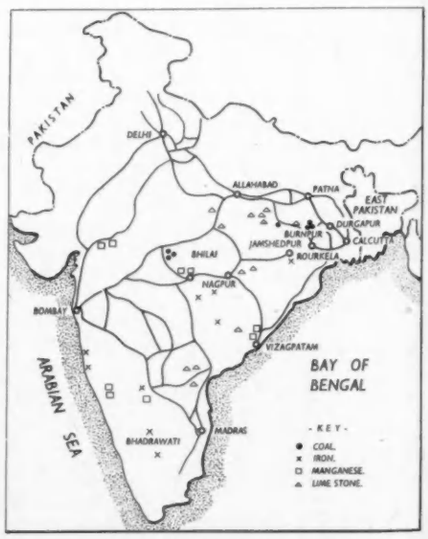
State	Million tons	Fe. Content, per cent
Bihar and Orissa	8,000	60/68
Madhya Pradesh	7,000	55/68
Madras	1,000	40/65
Mysore	2,500	55/65
Bombay	1,000	40/65
Andhra	130	60/68
Others	2,000	40/65
	21,630	—

The best available coking coals in India are in Bihar and Madhya Pradesh, but unfortunately they have a high ash content. Coal washing installations to help make metallurgical coke have largely been operated by the Tata Company whose washeries at West Bokaro and Jamadoba will soon be augmented by five further Government washeries one of which—a 500 tons an hour installation at Kargali—is now in operation. It is largely due to the shortage of suitable coke that the Indian National Metallurgical Laboratory at Jamshedpur has long been engaged in the pilot plant experiments with a low shaft furnace.

The large available quantities of limestone and dolomite are not of good steelmaking quality. Better grades of these materials do occur but they are far from the steel plants and costly to transport. It is expected that by the end of the Third Five-Year Plan the refractory brick making capacity will be 1,000,000 tons a year. This will be capable of meeting all foreseeable industrial requirements—with the steel industry operating at 6,000,000 ingot tons a year, it is estimated that 400,000 tons of refractory bricks will be required. Future expansion of the steel industry and the requirements of other industries will eventually absorb the estimated total.

Exploitation of India's raw materials will improve steadily as transport facilities are developed. The central Government's awareness of the need to improve transport and communications is reflected in the allocation of monies under the Third Five-Year Plan—over £1000 million of the total expenditure in the period is to be devoted to improvements and extensions. Some 20,000 miles of new roads and 1200 miles of new railway lines are prominent features of the programme.

A third new steel works, at Bhilai, is of Russian construction



Raw materials distribution in India

TABLE VIII—*Expected Annual Demand by* 1965–66.

		Million tons	
1.	Railways	1·20	All types
2.	Steel processing industries...	0·80	Heavy and light structurals, bars, rods ; sheets (black and galvanised) spring steel, wire, skelp, strip and tinplate
3.	Govt. development schemes	0·60	Heavy and light structurals, bars, rods, sheets and plates
4.	Public industrial development	0·60	As above, plus hoops and strip
5.	Industrial maintenance and packing	1·00	Black sheet, wire nails, tinplate, hoops
6.	State requirements (including agriculture)	1·00	All types
7.	Export...	0·30	Heavy and light structurals, hoop, strapping
8.	Defence	0·20	All types
9.	Reserve	0·30	All types
	Total	6·00	

MARKETS

It is clear that the Indian steel industry is undergoing rapid and extensive changes and expansions—the raw material requirements for the industry are known to be available and plans have been formed for their supply. But the markets for the products to be made will have to be assessed with foresight in order that the high capital cost of steel-making plant can be justified. The 6,000,000 tons a year of finished products which will result from current expansions are broken down in Table VIII under the various departments to which Indian steel is allocated. The table shows the anticipated pattern of demand for 1965–66 and (see item 7) substantial exports are clearly not in mind even at a period when the industry will have reached a high level of efficiency. This is not attributable to export hazards, but is entirely due to the high level of domestic consumption anticipated in the fields of industry, communications, building, agriculture, &c., under the current and future Five-Year Plans.

Optimistic forecasts of export potential must be tempered by an appreciation of the difficulties likely to be encountered. Japan and to a lesser degree China are well equipped to meet their own requirements and, indeed, offer fierce competition to any Indian sales venture in iron and steel. India's underdeveloped neighbours are potential buyers, but they have not the engineering capacity to absorb large quantities of steel. It is therefore vital that India builds up her engineering industries to enable her to export finished products. Although little is known of the true state of China's industry, it can be assumed to be in the ascendant and probably to an extent which will have a considerable impact on Indian industry as a whole. India's advantages of low labour costs and mineral wealth are likely to be partially offset by the high transport costs which would attend any efforts to export further afield.

The need to expand the domestic consuming industries has been mentioned earlier and can be equated to the need for a higher standard of living. But a sound domestic industry is also the best basis for establishing an active export trade. In addition, a consumer industry will assist in attracting foreign investment (assembly plants, licensed manufacture, &c.), and in creating local employment and the absorption of a high percentage of semi-skilled and unskilled labour. It will also give India a much better chance to compete internationally—as the labour content and cost is much more significant in the manufacture of consumer goods than in a basic industry like steel.

CONCLUSIONS

The question of expansion or consolidation requires an early answer. To presuppose a demand for yet more ingot steel and to solicit the necessary finance on that basis alone is not enough. India must be convinced and be able to convince potential creditors of her ability to consume the steel to be produced. The need for more steel is obvious ; even at to-day's rate of expansion it will be many years before the consumption of steel per head will approach a level compatible with a reasonable standard of living.

The natural resources to support a vast steel industry are there as is the will to make it succeed. More doubtful, however, is the availability of capital. This and two other major problems are interrelated ; first the ability to consume ingot steel by expanding engineering industries and secondly providing a supply of skilled labour to man these industries (steel fabrication and consumer goods manufacture require a much higher quantity and quality of labour than steel-making). Expansion of engineering industries has been investigated at intervals and plans for the development of industry in the public sector have been put forward. But it is doubtful whether engineering capacity is keeping pace with steel expansion.

Britain has much to offer in helping India to create engineering facilities and it is to be hoped that British interests will not allow this opportunity to go to her competitors. The impact of India's fast developing steel industry will be felt directly by all sections of the community. In the foreseeable future the untold fringe benefits which follow in the wake of an expanding steel industry will be available to the people of India—nowhere will they be more welcome or more richly deserved.

Some Notes on Locomotive Power

By E. C. POULTNEY

Since the introduction of diesel-powered locomotives for main line services on British Railways, exhaustive tests with representative examples of this type of motive power have been carried out. The relative performance of four locomotives with electrical transmissions is examined, together with the results obtained with a diesel-hydraulic locomotive, and a comparison is made with steam power

THE principal object of this article is to offer some observations on the performance of representative diesel-powered locomotives now in main line traffic on British Railways. Five test report bulletins have been published, describing the test results of diesel-electric locomotives ranging in powers of from 1000 h.p. to 3000 h.p. In addition, information is also available concerning the test performance of a locomotive fitted with an hydraulic transmission, which may, therefore, be included, thus adding interest to this review of the powers available with this new form of motive power.

The diesel-electric locomotives forming the subject of this discussion are enumerated as follows :—

(1) 2000 h.p. $1C_0$-$C_0$1. locomotive, Bulletin 16.

(2) 1750 h.p. $1C_0$-$C_0$1. locomotive, Bulletin 9.

(3) 1250 h.p. A.I.A.-A.I.A. locomotive, Bulletin 14.

(4) 1000 h.p. B_0-B_0 locomotive, Bulletin 11.

The diesel-hydraulic locomotives are being built at Swindon for service on the Western Region, B.R. They have the B_0-B_0 wheel arrangement and have Maybach diesel engines and the Maybach " Mekydro " transmission, employing a single hydraulic torque converter and four-speed mechanical gear assembly. These locomotives have been fully described by Mr. G. E. Scholes in a paper read before the Institution of Locomotive Engineers, November, 1959.

In addition to the diesel-electric locomotives mentioned, a further bulletin, No. 19, described trials made with the experimental 3300 h.p. diesel-electric locomotive " Deltic," not included in the present survey. A number of these large locomotives will ultimately be used for the heaviest passenger services, but for present purposes their high power makes reasonable comparisons of performance impossible. The results of the tests made with this locomotive were fully described in THE ENGINEER, July 11, 1958.

LOCOMOTIVE POWERS COMPARED

The accompanying tabular statement sets out certain particulars of the five diesel locomotives. When comparing the relative powers attainable at maximum output, drawbar horsepower is taken as being the criterion of performance for the reason that it is proportional to the work done, measured in ton miles per hour. With this in mind two graphs have been prepared, Figs. 1 and 2, showing respectively the full power drawbar horsepower characteristics for the diesel-hydraulic locomotive and for the five locomotives ; Fig. 2 also includes three additional curves showing the powers required to haul trains of passengers coaches at running speeds of from 40 up to 90 m.p.h. on a level tangent track.

Referring to the table, the first four locomotives are those with electric transmissions, numbered 1, 2, 3 and 4, and the remaining example, 5, is the diesel-hydraulic locomotive. The numbers given in the table are transferred to Fig. 2, thereby indicating the appropriate horsepower characteristics, which, taken in conjunction with those showing the powers required for each train, show the relative hauling capacity of each locomotive. The table consists of ten columns, giving in the first place the wheel arrangement and the locomotive number. Then follow columns 2 and 3, showing the nominal brake horsepower of the diesel engine or engines, as the case may be, and the actual powers developed on test when this is given in the report. The following columns, 4, 5, 6 and 7, show the relative performance of the locomotives at an operating speed of 50 m.p.h. on a level tangent and when the diesel engines are developing the powers given in column 3.

RAIL TRACTIVE EFFORT OR HORSEPOWERS

The terms " rail tractive effort or horsepower " are commonly used when investigating the performance of diesel-powered locomotives. This is the tractive effort

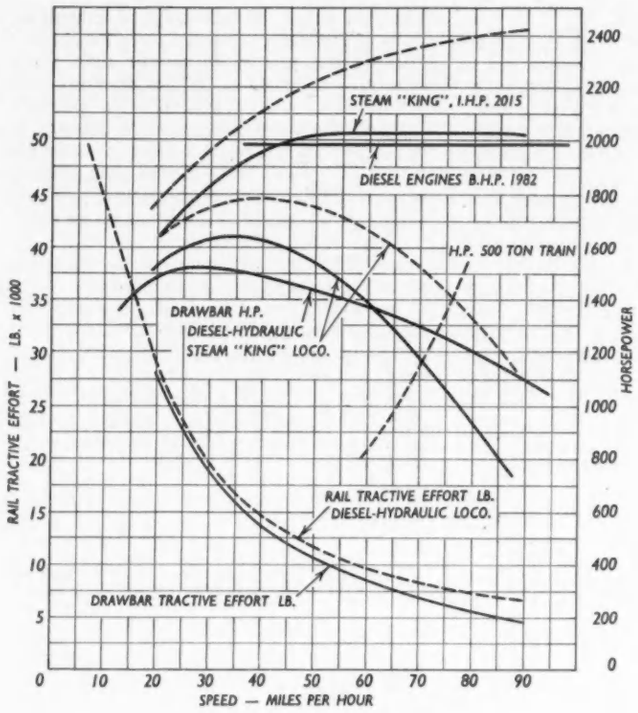


Fig. 1—Horsepower characteristics, diesel-hydraulic locomotive No. 801 and "King" class steam locomotive No. 6001

measured at the rims of the driving wheels and the difference between the values so obtained and the indicated effort developed in the cylinders measures the losses due to machine friction, thus enabling the mechanical efficiency of the engines to be computed. It is only when locomotives are tested on the stationary plant that rail tractive effort or horsepowers can be properly determined. When applied to diesel-electric locomotives, "rail" tractive effort or horsepowers, as the case may be, are not, strictly speaking, the same as in the case of a steam locomotive. In this case, the term "rail" tractive effort actually corresponds to the power delivered by the traction motors through the reduction gearing connecting with the axles of the driving wheels. The actual tractive effort exerted at the rims of the driving wheels would, therefore, be less according to frictional losses due to axlebox journal bearings. Such losses would, however, be relatively small.

In the case of diesel-electric locomotives, "rail" tractive effort or horsepower may be accurately determined before the electrical equipment is assembled on the locomotive, making it possible to construct what are called in the test bulletins "Designed Rail Tractive Effort" characteristics plotted against running speeds miles per hour. All that is required to obtain the information necessary are data readily obtained on the test bed, such as the efficiencies of the main and auxiliary generators and the combined efficiencies of the main and auxiliary generators and the combined efficiencies of the traction motors and reduction gearing. An example, based on experimental data derived from bulletin No. 14 describing the performance on test of locomotive No. D.5516 (Table No. 3), will serve to indicate how "rail" horsepowers or equivalent tractive efforts and transmission efficiencies are computed.

Rail Horsepower and Transmission Efficiency

The diesel engine developed 1255 b.h.p. when working at full power, and the established power losses between the engine and the power output by the traction motors, including the reduction gears, are given by the test report bulletin as follows:—

(*a*) To auxiliaries and radiator fan, 4·5 per cent.

(*b*) Main generator losses, 6·2 per cent.

(*c*) Traction motor losses, 8·3 per cent.

There is, therefore, seen to be a total loss of power between the engine and the power output by the traction motors of 19 per cent, so that the percentage of the power output of the diesel engine which is available for traction, measured at the axles of the driving wheels, is 81 per cent, and the actual "rail" horsepower is, therefore, 1255 by 81/100, 1015 h.p., equivalent to a "rail" tractive effort at 50 m.p.h. of $\frac{1015 \times 375}{50} = 7600$ lb.

The efficiency of the electrical transmission, including the reduction gears is, in this case, 81, based on the total full power output of the diesel engine. This would not, however, represent the true efficiency of the transmission system, because it includes the power absorbed by the auxiliary generator which powers the auxiliary equipment.

The actual efficiency of the transmission system would be measured by the difference between the power input to the main generator and the power output by the traction motors through the reduction gearing. In this case, the total combined losses amount to 14·5 per cent, which is the sum of the combined power losses of 6·2 and 8·3 per cent. The true efficiency of the transmission is, therefore, 100-14·5=85·5 per cent. The "rail" horsepower of 1015 h.p. is shown to be practically constant at all speeds from 20 up to about 50 m.p.h., meaning that the efficiency of the transmission is unaffected by the speed of the locomotive within the range given. The actual power absorbed by the locomotive when furnishing 1015 h.p. at the driving axles is 240 h.p. To this must be added the power lost due to the resistance offered by the locomotive, which is the difference between the "rail" and drawbar horsepowers.

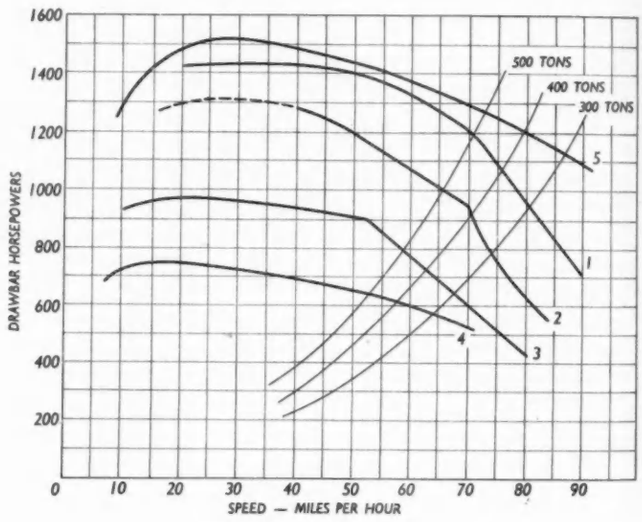


Fig. 2 — Diesel-powered locomotives; horsepower characteristics

British Railways—Diesel Powered Locomotives Comparative Performance

Constant Speed, 50 m.p.h.

No.	1 Locomotive wheel arrangement and number	2 Nominal b.h.p.	3 Actual b.h.p.	4 Rail h.p.	5 Drawbar h.p.	6 Transmission efficiency per cent	7 Traction efficiency per cent	8 Locomotive weight tons	9 Nominal b.h.p. per ton	10 Actual b.h.p. per ton
						Col. 4 / Col. 3	Col. 5 / Col. 3		Col. 2 / Col. 8	Col. 3 / Col. 8
1	1. C_o–C_o. 1 ... No. 10203	2000	1888	1540	1400	81·6	74·2	132·8	15·0	14·2
2	1. C_o–C_o. 1 ... No. 10202	1750	—	—	1200	—	—	135·0	12·9	—
3	A.I.A.–A.I.A. ... No. D5516	1250	1255	1015	910	81·0	72·5	104·0	12·0	12·06
4	B_o–B_o ... ... No. D8000	1000	1000	750	650	75·0	65·0	72·7	13·7	13·7
5	B_o–B_o ... ... No. 801	2112	1982	1567	1435	79·1	72·4	78·0	27·0	25·4

Locomotive No. 5. Two diesel engines of 1056 b.h.p. at 1440 r.p.m. Total 2112 b.h.p. Locomotive No. D800 and No. D802.

Locomotive Resistance

What is called the resistance of the locomotive is the difference between the "rail" tractive effort and the pull or tractive effort exerted at the drawbar as recorded by the dynamometer car at any given speed, miles per hour, when running on a level tangent track. The resistance values so obtained include machine friction, track and air resistances. The machine frictional losses are due to axlebox journal friction.

Referring again to the 1250 h.p. diesel-electric locomotive bulletin No. 14, the principal power losses, expressed in terms of horsepower between the actual engine output of 1255 h.p. and that shown at the locomotive drawbar, would be as below :—

Engine output	1255 b.h.p.	240
Rail horsepower	1015 b.h.p.	
Drawbar horsepower ...	910 b.h.p.	105

The total loss is, therefore, 345 h.p.

The drawbar horsepower of 910 corresponds to a drawbar tractive effort of 6830 lb and to a running speed of 50 m.p.h.

Diesel-Hydraulic Locomotive No. 801

Turning attention to the diesel-hydraulic locomotive, the efficiencies shown in the table, columns 7 and 8, have been computed as for the diesel-electric locomotives, the actual collective horsepowers of the two Maybach diesel engines of 1982 b.h.p. being assumed to be available for traction. The item "Rail Horsepower" is taken as being the power transmitted through the final gearwheels mounted on the driving axles. The actual power delivered at the rims of the driving wheels would actually be the power measured at the axles less any loss due to journal friction, possibly negligible with the type of axlebox commonly fitted to the locomotives of this description. In fact, this is apparently the case, because the "rail" tractive effort characteristic officially constructed has been used to determine the factor of adhesion at different rates of power output. The horsepower characteristic given by Fig. 1 has been developed from a set of large-sized curves kindly supplied to the writer by Mr. R. A. Smeddle, C.M. and E.E., Western Region, B.R., Swindon. The curve giving the rail tractive effort at speeds from 20 to 90 m.p.h. has been shown as a smooth curve, drawn as an average line through plotted points, and is believed to be an accurate representation. Locomotive resistances have been computed from a large scale diagram, making it possible to obtain the required resistance values for each running speed miles per hour. The power of this locomotive is remarkable in relation to its full working order weight, and the drawbar horsepowers indicated are of interest when seen in relation to a similar characteristic drawn for the 2000 h.p. diesel-electric locomotive No. 10203.

Diesel and Steam Locomotives Compared

Referring further to Fig. 1, showing the drawbar horsepowers developed by the diesel-powered locomotive No. 801, it will be seen that a further set of curves has been added to show how the new power compares with the older steam motive power. In view of the fact that the diesel-hydraulic locomotives will operate on the Western Region, the performance of the "King" class locomotives may be considered. An engine of this class, No. 6001, has been tested on the Swindon plant. The characteristics shown for this locomotive have been developed from the tests made on the testing plant, and apply to the results obtained when the steam supply to the cylinders was 30,000 lb per hour, giving an indicated horsepower of 2015 at speeds above 50 m.p.h., which compares closely with the power output of the two diesel engines of 1982 b.h.p., which, if referred to the cylinders, would possibly be rather more than 2100 h.p., depending on the mechanical efficiencies of the engines.

The two drawbar horsepower curves for the diesel and steam locomotives are interesting. They show that at comparatively low speeds the "King" class engines are the more powerful of the two, though its rated tractive force is less at 40,300 as against 48,000 lb for the locomotive No. 801. Experiments carried out with the "King" class locomotives have resulted in improving their performance by raising the evaporative capacity of their boilers, which is reflected by the high powers now possible. As now running, these locomotives have a large power available at normal speeds, but, when compared with the diesel locomotive No. 801, are much less powerful when speeds exceed 60 m.p.h. and operating under the conditions mentioned.

Such being the case, it is reasonable to consider if further improvements are possible whereby the "King" class engines could more effectively compete with the new locomotives at higher working speeds.

"King" Class Engines Improved

One of the most noticeable features seen when considering the performance of the "King" class locomotive No. 6001 when tested on the Swindon plant is the fact that the cylinder powers developed remain sensibly constant at all speeds in excess of 50 m.p.h. There is, therefore, seen to be a constant and practically regular fall in the indicated mean effective pressures, which appears to be almost exactly inversely proportional to the increase in speed. In other words, the product of mean pressure values and speed is closely equal from 50 up to 70 m.p.h. After that speed cylinder powers tend to fall. It is evident that the valves and valve gear set a limit on the cylinder performance at high speed, because, instead of powers increasing with speeds as they should, they remain about constant, the result of which is seen in the rapid loss in drawbar horsepowers available through the higher ranges of speed. Fortunately, means are available for materially improving cylinder performance, especially at high running speeds. The effect of such improvements is shown by the broken line curves in Fig. 1, which indicate the cylinder powers possible with the existing cylinders and with the same rate of cylinder feed steam by adopting a modern and vastly more effective valve gear and steam distribution. On the allowable assumption that drawbar horsepowers would increase in proportion to the increase in cylinder powers, the improved "King" class locomotive would develop the same drawbar horsepower at 90 m.p.h. as the diesel locomotive No. 801, even though the locomotive weighs 135 tons as against 78 tons for the diesel locomotive. The new cylinder power curves are derived from the Swindon tests made with the B.R. Standard 4-6-2 locomotive class "8." This is made possible because it so happens that the rated tractive efforts of these two locomotives are almost equal, being, for the "King," 40,300 lb, and for the class "8," 39,080 lb ; thus the former is 3 per cent more powerful than the latter. The boiler working steam pressures are the same at 250 lb per square inch. In each instance, the rate of cylinder feed steam is 30,000 lb per hour. The "King" has a slight advantage by having a rather larger cylinder volume and because, at equal speeds in miles per hour, revolutions per minute would be rather lower on account of its having 78in as against 74in drivers for the class "8" locomotive.

If the performance of the "King" class engine is compared as now in service and after modification as suggested, the following results would be obtained :—

Steam per hour, lb	30,000
Water per hour, lb	28,400
Coal, per hour, lb	4065
As running. Constant speed 60 m.p.h.	
Drawbar horsepower	1380
Water, lb per drawbar horsepower	20·6
Coal, lb per drawbar horsepower	2·94
As improved	
Drawbar horsepower	1660
Water, lb per drawbar horsepower	17·1
Coal, lb per drawbar horsepower	2·44

At 80 m.p.h., the "King" class as now running develop a drawbar horsepower of 940 and as improved, this would be increased to 1320, or 40 per cent. The relative powers available for hauling trains for the "King" class and the diesel-hydraulic locomotive are clearly seen from the characteristics given in Fig. 1. The "King" class locomotives can, if required, be considerably more powerful at all speeds than the diesel-hydraulic locomotive.

Diesel Locomotives Compared

The horsepower characteristics shown by Fig. 2 call for some notice. They are particularly interesting because they indicate clearly the relative full power curves of horsepowers available to operating trains on a level tangent track. The powers of the locomotives concerned vary from 1000 h.p. to 2000 h.p. The superimposed curves relate to trains of passenger stock of 300, 400 and 500 tons, covering a range of loads applicable to the powers of the diesel locomotives. They indicate the balancing speeds attainable by each locomotive with each train. When estimating the horsepower required per ton values, the specific train resistances used are as given by Mr. O. S. Nock, writing to The Engineer of December 19, 1958, "Mechanics of Train Running." Further, it may be of interest to note that the values so obtained do not vary greatly from a curve of horsepower per ton values derived from the well-known Davis (G.E.C. America) formula, which happens to be about the mean of eight similar resistance curves given by Dr. Tuplin, "Drafting and Observance of Train Schedules," The Engineer, October 22, 1954. The curves of horsepower for the two 2000 h.p. locomotives, No. 10203 and No. D801, will no doubt attract attention. The former has one engine developing on test 1888 b.h.p. and the latter two engines, giving on test a total of 1982 b.h.p.

In view of the greater weight of the diesel-electric locomotive of 132 tons and the larger number of axles, eight in place of four in the case of 78-ton diesel-hydraulic locomotive, the diesel-electric example compares favourably with the later design, especially when the relative actual powers developed by the engines are remembered. In so far as the powers shown in relation to the weight of the three trains are concerned, it must be remembered also that, as the locomotives are all working at full power, the train loads given would be substantially reduced in actual practice. Finally, the horsepower characteristics are of interest as summarising the power capabilities of five representative diesel-powered locomotives, while at the same time the remarks offered on the diesel-steam comparison would appear to indicate the desirability of making similar comparisons between examples of rail motive power only when both these different power units are of the most modern design according to the latest state of the art.

LETTERS AND LITERATURE

Letters to the Editor

MILLIONS TO BE SAVED

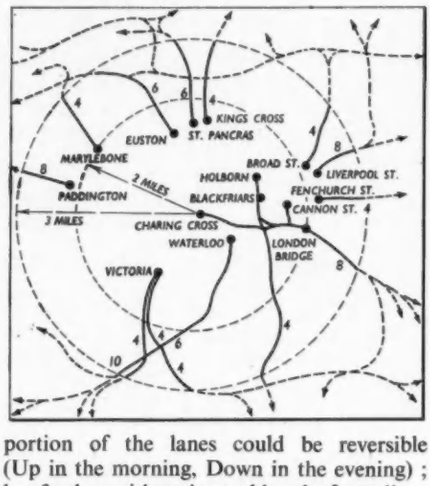
SIR,— Mr. O. S. Nock asks how the daily flow of some 20,000 medium-distance passengers, between London and the provincial centres 50 miles to 200 miles out, would be provided for after the railways had been turned into motor roads.

In the first place the substitution of free-running single vehicles, in the form of buses, for the present trains of up to fourteen coaches would result in services of greater frequency, with a higher proportion of express runs. Possibly (though not necessarily) the maximum speed of the buses would be lower than that of the fastest trains at present, but it is safe to predict that the overall journey-speed of the average passenger, to or from his home front door, would improve.

On the subject of passenger comfort it has to be realised first that the word " bus " need not for ever, as it does for the present, connote discomfort. It conjures up a picture of too short a vehicle (30ft maximum legal length), bumping along an ill-kept highway, chock-full of passengers seated in the posture of an Indian faquir. This sort of thing would be quite unnecessary on the converted railways. The extra space obtainable by lengthening the vehicle could —and should—be used to give the passengers all the luxury of air travel, first class. It is only by measures such as these that public service passenger transport will ever flourish in straight competition with the motor-car.

The long wheelbase of these vehicles would yield the further advantage of steadier riding. But in this respect, the chief advantage, which would accrue to all the vehicles using the converted railways, would derive from the supreme evenness of road surface that could be specified and achieved during the actual conversion. The Crowthorne test track has been surfaced to a tolerance of $\frac{3}{16}$in under a 10ft straightedge, with long undulations eliminated by keeping within $\frac{1}{4}$in of the level specified ; the techniques and machinery are improving constantly; one can be confident that, even if railway conversion came soon, it would herald a new era of passenger comfort, including the novelties of steadiness and silence.

Finally Mr. Nock asks for a look at the bus traffic that would replace his " swarm of expresses leaving London between 4.45 p.m. and 6.30 p.m." Let it be assumed that the buses are forty-seaters ; in which case a total of 500 of them would have to set out from the dozen main line passenger termini in the $1\frac{3}{4}$ hours. As is shown in the accompanying sketch, these termini are served by a total of seventy rail tracks. Suppose each rail track were instead a road traffic lane, then the outgoing " swarm " of buses on the thirty-five " down " lanes would resolve itself into an average of 14·3 buses per lane per $1\frac{3}{4}$ hours—one bus per lane per seven minutes! Actually the rail tracks are wide enough to yield more than one lane apiece, and a proportion of the lanes could be reversible (Up in the morning, Down in the evening) ; but further arithmetic would make for tedium in replying to a very welcome letter, so I hope that my minimal outline will suffice to convince Mr. Nock that the medium-distance passenger traffic, even during the peak $1\frac{3}{4}$ hours, would be infinitesimal in relation to the capacity of the railroads serving central London after they had been turned into real roads.



T. I. LLOYD

Guildford,
February 5, 1960.

SIR,—One must have sympathy with the business men mentioned by Mr. O. S. Nock in your issue of February 3, but their business talks and breakfasts on the train are matters in which they might even be called upon to alter their habits, in the face of national crisis. In practice I do not doubt that after conversion of the railways they will look back in surprise at the standards of comfort which they thought satisfactory in the railway era. Airline passengers seem to find their comfort fairly well catered for and what can be done in the air should be possible on the ground.

Mr. Harding (in the same issue) seems to have no very clear conception of the railway conversion project. If many business men now prefer to face the discomforts of rail commuting, rather than the alternative discomfort of struggling with traffic jams, this is quite irrelevant to the case for railway conversion. At the moment one can have either the comfort of the motor vehicle or the freedom of movement of the reserved permanent way. Unfortunately, either choice means the acceptance of the concomitant disadvantages : in the first case, congested roads ; in the second case, waiting on draughty stations, broken journeys, noise, dirt, shaking and overcrowding. Railway conversion will marry the advantages and eliminate the disadvantages, creating an entirely new environment for travel.

If Mr. Harding thinks that the advocates of railway conversion are still " a voice crying in the wilderness " he is very much out of touch with the enormous progress towards general acceptance which this project has made. The only body of people who still behave as though they had not heard of the idea of railway conversion are the politicians ; for the reason that they are all (whatever their party allegiance) committed to the conflicting policy of railway " modernisation," which is based on the assumption that railways are a vital national industry. However, even politics are, in the end, sensitive to public opinion.

Mr. J. V. Walker (also in the February 3 issue) appears to consider it quite in order for railways to kill off people provided that the victims can be labelled " trespassers " or " industrial accidents." These unfortunate people are, however, just as much dead, and their deaths are just as much a result of the existence of railways, whatever the theoretical heading under which they are listed.

I am wondering whether the time has not arrived for the critics of railway conversion to put forward the alternative remedies for the present traffic crisis. The situation must be resolved without delay, but although the railway conversion project has stood up to prolonged hammering and sniping, and come through this with added strength, it should not be accepted as the correct course of action until the alternatives have been examined.

M. J. DOUGLASS

Railway Conversion League,
Guildford,
February 4, 1961.

SIR,—In his letter published on January 20, Mr. M. J. Douglass refers to the prospect of abandoned permanent way being diverted to other than transport uses.

This deprivation is already taking place, if only by neglect, on a short but vital length of converted railway. I refer to the crossing of the Nene at Sutton Bridge by the combined road and rail bridge, which forms the shortest link between North and West Norfolk, on one side of the Wash, and the Midlands and the North of England on the other.

The original carriageway of this bridge is too narrow for two lanes of modern heavy traffic, and it has long constituted a serious bottleneck at peak periods. The railroad section was " converted," by lifting the rails and repaving to accommodate road vehicles, when the railway was closed some two years ago. But this section of the bridge has not yet been opened to public transport.

Apart from red tape, the only action now required to provide free traffic flow at all times is the removal of barriers and the installation of " Keep Left " signs at the bridge ends.

Either the Transport Commission has been playing " dog in the manager " or the highway authorities have been unaware of their duty to the public in this matter.

E. H. BATEMAN

Farnham, Surrey,
February 2, 1961.

IS THIS A RECORD ?

SIR,—Twenty-five years ago we supplied an electric trawl winch for the French trawler " Mercedita." The vessel has now passed into Greek hands and the new owners have asked for a wiring diagram. Ordinarily this would not surprise us, but we are informed that the vessel was sunk three times during the war. The letter adds " The equipment is all in very good condition."

We are used to making marine electrical equipment that outlasts the ship, but after three sinkings we really think we might expect an opportunity to quote for replacements! All we get out of this performance is a request for a wiring diagram (with which we shall send a copy of " Instructions for Drying-out Electrical Equipment," for possible future use!).

T. J. BARFIELD,
Publicity Manager,
Laurence, Scott and Electromotors, Ltd.,
Strand, London, W.C.2,
February 1, 1961.

Book Reviews

More Unusual Railways. By JOHN R. DAY, A.M.INST.T., Assoc.I.R.S.E. Frederick Muller, Ltd., Ludgate House, 110, Fleet Street, London, E.C.4. Price 21s.

IT has sometimes been suggested that railway enthusiasts prefer to read about the things they know, and that a railway book should tread familiar paths, albeit illuminating the scenery with new contrasts of light and shade according to the author's fancy. This is probably still a safe formula, but the existence of a healthy appetite for the rare and strange is proved by the title of the present book. Having whetted it by *Unusual Railways*, Mr. Day has returned to the theme with undiminished enjoyment (which he communicates to his readers) and unflagging patience in research to provide his public with *More Unusual Railways*.

The selection in this volume ranges wide, for it includes unfamiliar forms of propulsion on conventional permanent way. The horse and the sail find their place, and it may surprise many to realise the extent to which the horse continued to be used for hauling passenger vehicles after the first steam locomotives had appeared. Monorails occupy four chapters, divided into suspended and supported systems. Two further examples of the Lartigue principle are among those described, one of which, from Feurs to Panissières in Normandy, did not even wait until after the opening ceremony to indulge in its " teething troubles," but deposited the official party gently on the ground in the course of its inaugural run. The subject of monorails is of growing topical interest and various urban transport schemes realised in recent years or now in prospect are dealt with in some detail. This applies also to the chapter on guide-rail systems, which describes the proposed track construction and vehicles for an " Air-Rail " route between London, Victoria, and London Airport. An idea which would enable ordinary vehicles to be adapted for rail-guidance on suitable sections of their journeys, and be steered normally elsewhere, is the Kuch " guided road " system, and similar principles adopted or proposed in various places show continuing awareness that both road and rail have limitations which might be lessened by combining their characteristics for certain transport functions.

The final chapters of the book deal with the " Talgo " system and similar forms of articulation in rolling stock, and with various special-purpose lines which include rocket sled tracks for testing aircraft and missile components. The author has gathered his information from a very wide field, and his narrative is not only readable in itself but enlivened by quotations from contemporary accounts of some of the earlier projects.

The Brittle Fracture of Steel. By W. D. BIGGS. Macdonald and Evans, Ltd., 8, John Street, London, W.C.1. Price 70s.

" EFFECTS of percussion and frost upon iron . . . . We need hardly say that this is one of the most important subjects that the engineers of the present day are called upon to investigate. The lives of many persons, and the property of many more, will be saved if the truth of the matter be discovered—lost if it be not. "

That quotation from THE ENGINEER leading article, June 18, 1861, has been printed on the page preceding the Introduction to this new book. The subject has obviously been of practical importance ever since steel commenced to be widely used. When modern bridges, storage tanks, and ships failed catastrophically because of the brittle fracture of steel during the past twenty years, every engineer was deeply concerned.

Accustomed as we have been to see steel elongate plastically when strained beyond the yield point in a tensile test, and to neck visibly before rupturing, design staffs were naturally perturbed when large steel structures on land and sea were reported to have failed suddenly, with little or no prior deformation of the steel. The author has therefore designed this book to provide a comprehensive review of the present knowledge on the brittle behaviour of structural steels. Its 420 pages of 9in by 5½in are printed with admirable clarity and divided into thirteen chapters, fourteen pages of subject and author indexes, and three appendices, and include seventeen tables and 242 illustrations.

In the first two chapters fractures are classified and reference is made to brittle fractures that have been reported. More than a dozen riveted merchant ships have broken in two or are listed as missing, whilst such famous liners as " Leviathan " and " Majestic " suffered fractures across the strength deck. Because of the risk of fracture in cold frosty weather it was normal practice to heat the plates to avoid cracking between rivet holes and plate edges during their punching by shipyard workers.

There were thirteen reported cases of failure in riveted structures, mostly storage vessels, between 1886 and 1937. The author tabulates details of the failures in twenty-seven cases of brittle fractures in structures other than ships. Most of these were failures of welded structures during the past twenty years. But the spectacular failure in January, 1919, of a 90ft diameter and 50ft high riveted mild steel tank, only three to four years old, containing about 2,000,000 gallons of molasses at Boston, U.S.A., belongs to the period before welding was so widely adopted. In the same chapter he records the structural performance of various types of welded ships, up to March, 1953, as summarised by Parker, thus : out of 4694 welded ships, 233 suffered fractures, which so weakened the main hull that the vessel was lost or in a dangerous condition ; a further 1056 casualties involved the main hull structure at a position which is potentially dangerous.

Brittle fracture of steel is not confined to these spectacular massive structures. There is an irritating incidence of brittle behaviour in domestic articles that are frequently made by cold pressing from low grade Bessemer steels, with a sublime disregard of the marked strain-ageing characteristics.

This relatively short introduction, that makes abundantly clear the great practical importance of brittle fractures in service failures, is followed by the three longest chapters in the book. They describe, with the aid of many clear diagrams, the mechanical aspects of flow and fracture in steel, and the nucleation of fracture. Then come chapters dealing with notch impact and other mechanical tests ; their variety is great, from slow tensile tests to explosion testing of steels. The correlation of all this mass of test results must proceed for many a day. Moreover one must bear in mind the effect of metallurgical variables on the results of notched-bar tests ; what part welding and residual stresses play in brittle fracture. These aspects of the problem are systematically discussed by the author in the three chapters preceding his final fifteen page summary. Each chapter is concluded with a list of the useful references ; in all they number 865.

Clearly, we now know more about brittle fracture now than we did in 1861 ; but unfortunately the designer still cannot be offered any panacea against the brittle fracture of steel. Current ideas on service failures appear to fall into one of the following two categories :—

Either that any structure, however carefully constructed, contains localised areas of high stress concentration so that the initiation stage of fracture is already taken care of, if not *ab initio* then at least by the first application of the working stress when local yielding and strain hardening occur. Under such circumstances the object of the test would be that of determining the conditions under which the propagation of an existing crack would be impeded.

Or that the available evidence indicates that a brittle crack will propagate under a low stress whereas a significantly higher stress is needed to cause initiation—the so-called initiation barrier. Providing that adequate measures can be taken to minimise the presence of stress concentrations it can be argued that this barrier constitutes a higher margin of safety in the structure, and that therefore the material should be selected so that initiation does not occur under the anticipated working conditions.

Thus it may be concluded that although the great research effort since the S.S. " Schenectady " broke her back in 1943 has done much to reduce the probability of brittle failure in large structures, more critical experiments are needed before optimum conditions can be established. In the long run the way to a full solution of the problem must lie through a deeper understanding of the fundamental mechanisms of metal flow and fracture.

The author, W. D. Biggs, B.Sc., M.A., Ph.D., has been a member of the Iron and Steel Institute since 1946 and served in the Research Department of Murex Welding Processes, Ltd., before joining the University of Cambridge, Department of Engineering, Engineering Laboratory, Trumpington Street, Cambridge. Engineers and metallurgists who, in the pursuance of their normal duties, may be brought into direct contact with one or other aspect of the problem of the brittle fracture of structural steels, will welcome this very skilled review of the whole problem.

LETTERS AND LITERATURE *(continued)*

Silicones. Edited by S. FORDHAM. George Newnes, Ltd., Tower House, Southampton Street, Strand, London, W.C.2. Price 36s.

THIS book is a co-operative production, being the work of thirteen specialists, each dealing with a particular field of silicone technology. Individual notes by the several authors have been brought together by the editor, Dr. Fordham, in a form which will be of value to the general reader. The book is in two main parts. Following a brief historical introduction there is a condensed account of organosilicon chemistry with sufficient detail to give the reader a general understanding of the present position in the field. The second part of the book is an outline of the industrial manufacture and application of silicones. It is here that engineers generally will find the greatest interest. Some 12,000 to 14,000 tons of silicones are produced annually throughout the world, and not only are many uses found for them at present, but new uses are being developed. In the industrial world the peculiar properties of silicones have rendered them of particular value in textile manufacture, paper treatment, polish manufacture, electrical insulation, and mechanical rubber goods production. These major uses and many minor ones, are dealt with, and there is an assessment of future prospects.

Research on the Rolling of Strip. A Symposium of Selected Papers, 1948–58. British Iron and Steel Research Association, 11, Park Lane, London, W.1. Free to B.I.S.R.A. members; price to non-members, 21s.

THE period covered by the seventeen papers in this volume was, as the preface says "... particularly productive of original papers on the mechanics of strip rolling." They are, however, rather scattered, and they have been brought together in the present volume to make the information accessible in a single source. The papers are chosen to show the gradual development of practical and reliable methods of rolling mill calculations from basic theory, and their presentation in this form is particularly appropriate at the present time, when developments in rolling mill design and control are taking place so rapidly.

In the period under review a tendency to greater complexity in rolling theory has been reversed, and as a result of the researches described, together with the growing volume of accurate experiments, it is now possible to simplify the calculations without serious loss of precision. Reliable methods of calculating roll force and torque for a wide variety of conditions are now available, and they can be supplemented by the use of electronic computers and nomograms.

Stresses in Shells. By WILHELM FLUGGE. Berlin–Göttingen–Heidelberg: Springer-Verlag, Berlin–Wilmersdorf, Heidelberger Platz 3. Price DM.58.80.

WHILE dealing with the subject of stress in shells from the theoretical angle, the author has sought to avoid writing a mathematical treatise in the guise of a mechanical subject. Throughout he has endeavoured to keep the mathematics to the essential minimum, so that many sections do not presuppose more than a knowledge of ordinary differential equations with constant coefficients. In other parts ordinary equations with variable coefficients, product solutions of partial differential equations, the theory of complex variables, or numerical analysis are encountered. The kinds of shell dealt with include shapes of revolution, cylinders, elliptic, hyperbolic and arbitrary shapes which are considered from the angle of membrane theory, i.e. subject only to direct stresses. More complex cases where the bending stiffness of the shell cannot be neglected are dealt with in subsequent chapters which are concerned with cylinders and surfaces of revolution. In the concluding chapters will be found a treatment of the problem of buckling and of forces and deformations in circular rings. In presenting in this manner the basic facts of shell theory, the book will be found useful both by the engineering research worker looking for a starting point for his own work, and by the designer.

Berechnung und Gestaltung von Metallfedern. By SIEGFRIED GROSS. Berlin–Göttingen–Heidelberg: Springer-Verlag, Berlin–Wilmersdorf, Heidelberger Platz 3. Price D.M.21.

ALTHOUGH metal springs have lately tended to be superseded by other elastic elements, notably rubber, their place in machine design is still of the greatest importance. In a great many pieces of equipment, correct and trouble-free functioning depends upon the satisfactory design and adequate endurance of the springs which are incorporated. The great variety of steels and other materials from which springs are being made, the stringent heat-treatment required to enable the finished product to stand up to conditions which are often severe, and complex shapes not infrequently involved, call for great experience on the part of the designer. The present book is addressed both to the practical designer and the user of metal springs. In order to keep a large subject within a reasonable compass, with one exception all formulae are merely quoted and not derived. The bulk of the work is devoted to a thorough technical discussion, supported by sample calculations, of the three principal groups of springs, namely those subject to bending, torsion, and direct tension or compression.

Books Received

FBI Register of British Manufacturers, 1961. Thirty-third edition. Federation of British Industries, 21, Tothill Street, London, S.W.1. Price 21s.

Materials for Nuclear Engineers. Edited by A. B. McIntosh and T. J. Heal. Temple Press, Ltd., Bowling Green Lane, London, E.C.1. Price 75s.

Electricity Undertakings of the World. 1960-61. Seventieth edition. Benn Brothers, Ltd., Bouverie House, 154, Fleet Street, London, E.C.4. Price 35s. 6d.

Notes on Operations Research. Assembled by the Operations Research Centre. Crosby Lockwood and Son, Ltd., 26, Old Brompton Road, London, S.W.7. Price 30s.

Statistical Handbook, 1959. Volumes 1 and 2. British Iron and Steel Federation, Steel House, Tothill Street, Westminster, London, S.W.1. Annual subscription 63s.

Direct Current Machines. Second edition. By H. B. Ranson and E. T. A. Webb. Cleaver-Hume Press, Ltd., 31, Wright's Lane, Kensington, London, W.8. Price 21s.

Michael Faraday: A List of His Lectures and Published Writings. By Alan E. Jeffreys. Chapman and Hall, Ltd., 37 Essex Street, London, W.C.2. Price 42s.

Books of Reference

The International Dictionary of Applied Mathematics. Editor-in-Chief, W. F. Freiberger. D. Van Nostrand Company, Ltd., 358, Kensington High Street, London, W.14. Price 187s. 6d.—This volume defines the terms and describes the methods in the application of mathematics to thirty-one fields of physical science and engineering, which are discussed in sufficient detail to permit the adaptation of methods from related fields. There are more than 8000 entries and the result would be described in this country as an encyclopaedia; of lexicographic character, however, are indices in French, German, Spanish, and Russian.

Directory of Railway Officials and Year Book, 1960–61. Tothill Press, Ltd., 33, Tothill Street, London, S.W.1. Price £3.—The general arrangement of this, the sixty-sixth edition of the year book, is similar to that of the previous edition. The information it contains has been revised and brought up to date in the light of developments which have taken place in all parts of the world during the past twelve months. The revisions show the rapid extension of electric and diesel traction, whilst the reduction of mileages continues with the closure of branch and minor lines, particularly in this country and the United States. As in previous years the book provides a concise, complete source of reference for all connected with railway transport.

Transatom Bulletin. Vol. 1, No. 1, December, 1960. Information on Translations covering Nuclear Literature. Published monthly by Euratom, Brussels: European Atomic Energy Community, Transatom Service, 51, rue Belliard, Brussels. Price BF.50 per copy; annual subscription BF.400; air mail (non-European countries) BF.100 per copy; annual subscription BF.800.—The European Atomic Energy Community (Euratom), the United States Atomic Energy Commission and the United Kingdom Atomic Energy Authority have agreed to pool their efforts in order to collect and disseminate information on translations covering nuclear literature. To achieve this aim, an information office called "Transatom" has been set up at the headquarters of Euratom in Brussels. This office recently published the first issue of a monthly journal in English, *Transatom Bulletin*, which has the purpose of providing references to existing and planned translations, in particular those appearing in languages unfamiliar to Western readers. Translations themselves, however, are not obtainable from "Transatom," but should be requested from the organisations listed in the *Bulletin*. On the other hand, "Transatom" is building up a master card file where all data relating to translations of interest are being recorded, indicating where translations can be purchased or borrowed, and at what price and in which form. Information contained in this file is available to subscribers on request.

THE ENGINEER Buyers Guide

The 1961 edition of *The Engineer Buyers Guide* was published on February 3 and one free copy has already been despatched by post to all direct postal subscribers. All regular readers who buy THE ENGINEER through newsagents should also have had one.

Any subscriber or regular reader who has not yet received a copy should write to The Manager, THE ENGINEER, 28, Essex Street, Strand, London, W.C.2. Additional copies are obtainable at 10s. each (postage 2s. extra).

This latest edition contains 984 pages including the Buyers Guide Section (2700 classified products with 35,100 entries), Address Section (1860 firms) and lists of U.K. Agents for Foreign Firms, Trade Names, Associations, Institutions and Societies connected with the Engineering Industry, National Undertakings and Forthcoming Engineering and Industrial Exhibitions.

Motor Vessels for Tilbury-Gravesend Ferry

By G. W. TRIPP, O.B.E., F.C.G.I., M.I.C.E.

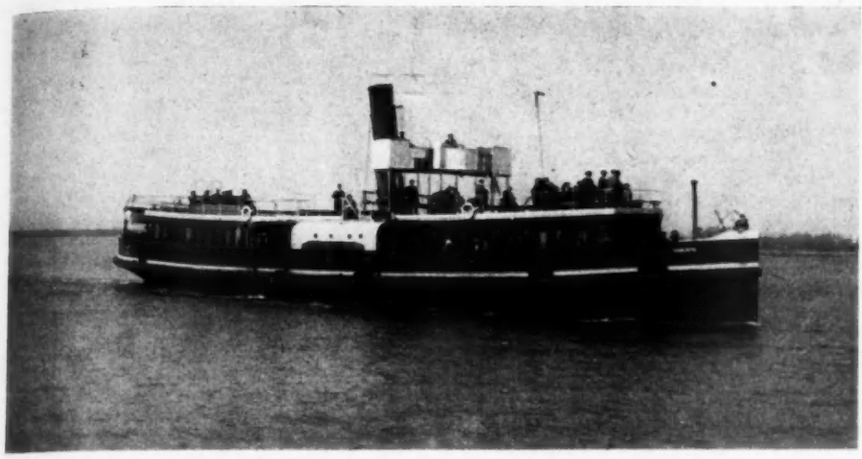


Fig. 1—London, Tilbury and Southend Railway's S.S. "Gertrude"

TRADITION has it that the service between Tilbury and Gravesend was inaugurated to take passengers across the River Thames from Tilbury to Gravesend to go to the Rosherville pleasure gardens, but in any case a ferry began to operate in 1850, being maintained by a private company until taken over in 1862 by the London Tilbury and Southend Railway with small paddled steamers, the last of which was the "Tilbury," built in 1883, to be followed by the first twin screw steamer "Carlotta" ten years later.

Between 1901 and 1911 four more steamers came into service named "Rose," "Catherine," "Gertrude" (Fig. 1) and "Edith." The dimensions of the last named were as follows: length, 131·6ft; breadth, 28·5ft; depth, 8·4ft; tonnage, 283 gross. She is driven by compound engines with cylinders 12in and 24in diameter and a stroke of 18in. With the exception of "Gertrude," which was sold to the New Medway Steam Packet Company and became the excursion steamer "Rochester Queen," the remaining three have maintained the ferry service up to the present day.

New motor vessels (Fig. 2) bearing the same names as their predecessors are about to be put into service. They are being built by Whites Shipyard (Southampton), Ltd., their leading dimensions being: length overall, 110ft; between perpendiculars, 105ft; breadth moulded, 27ft; draught loaded, 4ft 6in; tonnage, 213·74 gross. Each can carry 475 passengers, and has a crew of four. Each vessel is fitted with a six-cylinder Lister Blackstone uni-directional four-cylinder diesel engine type ER6M, developing 300 b.h.p. at 660 r.p.m. (twelve hour rating) driving a size 14E Voith-Schneider cycloidal propeller manufactured by Brown Brothers of Edinburgh. The combined speed and steering control pedestal is fitted in the wheelhouse (Fig. 3), thus putting the manoeuvring of the vessel under the control of the master. Auxiliary power is provided by two Lister Blackstone JK3MA 36 b.h.p. diesel engines, each driving a 15kW, 220V, d.c. Laurence Scott generator at 1200 r.p.m., one set driving in addition a Hamworthy general service pump and air compressor. The exhaust fumes are carried up beside the mast. A special feature of the new vessels is their being fitted with three gangways at each side, of the hinged folding type, hydraulically operated from the bridge, thus ensuring speedy embarkation of passengers. It is believed these are the first gangways of this type to be installed on a vessel.

Fig. 3—Interior of wheelhouse

Fig. 2—Tilbury-Gravesend passenger ferryboat "Catherine"

Fixed seating accommodation is provided for 202 persons, and there are two electrically-heated lounges on the lower deck, while there is separate accommodation for master and crew, equipped with a small electric oven and water boiler.

In order to minimise the effects of rust and corrosion extensive use has been made of plastic covering for hand rails and wire guards. A small rudder has been fitted for emergency purposes, operated by hydraulic gear controlled from the wheelhouse. VHF/RT equipment is installed in each vessel for navigational purposes in periods of poor visibility, for communication with the shore radar station at Tilbury.

It is a sad commentary on the kind of passenger carried that steps have had to be taken to minimise the opportunities for hooliganism and theft.

A demonstration cruise on the new "Catherine" took place on Tuesday, December 31, when the easy manoeuvrability and behaviour of the vessel were demonstrated.

Remote Control of Railway Signalling

Modernisation of railway signalling is now causing this specialised field to overlap in some directions with general industrial practice. Remote control and indication systems, and the application to them of electronic techniques, are subjects of wide interest, and the equipment described below forms a remote supervisory control system which could find various uses outside those for which it was primarily developed.

DURING the past eighteen months several signalling schemes have come into operation on British Railways in which self-contained interlockings are controlled from signalboxes several miles away. Installations of this kind on the Manchester-Crewe main line of the London Midland Region, and on the Eastern Region suburban lines in North-East London, make use of the "Westronic" system of the Westinghouse Brake and Signal Company, Ltd., to which we have referred briefly in our issues of September 16 and November 25, 1960.

The "Westronic" system in its basic form is intended for transmitting a large number of controls and indications between two fixed points, and need not be confined to railway signalling applications. It is applicable to purposes where controls are derived from two-state devices, such as switches or push buttons, and indications are related to the "up" or "down" conditions of relay contacts. One pair of line wires carries all controls and indications in a single-station installation. If more than one outstation is to be controlled, additional carrier frequencies or line wires can be used.

Considering a single-station scheme, each control switch is connected via the line circuit to its associated remote device (such as a signalling relay) on a specific step of a continuously-repeated cycle. During this interconnection, control and indication information is transmitted simultaneously and automatically according to the conditions of the two devices. The scanning cycle is controlled by a master stepping generator at the control centre, so that the counting chains at both ends of the system perforce receive stepping pulse signals of exactly the same repetition frequency. The stepping generator output is fed through pulse circuits to all counting chain stages in parallel at both ends of the system. In the block diagram of the system (Fig. 1), the stepping generator frequency is designated *f*5.

Each counting chain consists of a number of pairs of transistors, the actual number of such stages being equal to the number of devices to be controlled or of functions to be indicated, whichever is the greater. In any stage one transistor is normally conducting and the other non-conducting. A clamping condition is fed from stage to stage so that none can change over until the one preceding it has done so. At the beginning of the cycle all stages are normal. The first pulse changes over stage 1 only; this releases the clamp from stage 2, allowing this stage to respond to the next pulse, and so on.

Two functions occur when a stage changes over:

(1) A pulse of energy is routed via the function control switch associated with that stage at the control centre to a carrier frequency transmitter, causing one of two control frequencies, *f*1 or *f*2, to be transmitted, according to the setting of the control switch; similarly, at the outstation a corresponding pulse is sent to the carrier transmitter there via the function indication relay for that step in the cycle, causing indication frequency *f*3 or *f*4 to be transmitted back according to the condition of the relay.

(2) At each end of the system a signal is fed to the registry stage associated with the counting chain stage which has changed over, so that each registry stage is receptive to the incoming information. The output from the registry stages operates the electromechanical registry relays which form the link between the "Westronic" system, the controlled devices at the outstation, and the indicating devices at the control centre.

Each registry stage consists of a bistable pair of transistors similar to the counting chain stages, and is receptive only when its associated counting stage operates. Having changed, the registry stage remains in the condition to which it has been operated until reversed by reception of the alternative

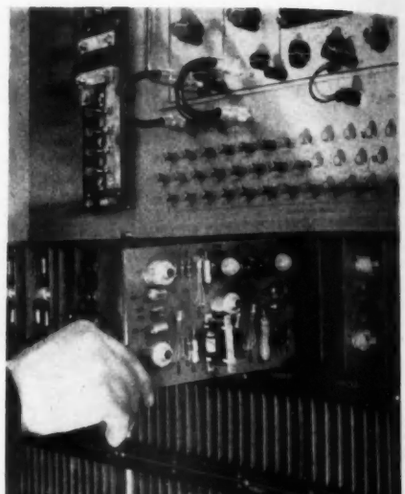


Fig. 2—Plug-in printed circuits, showing transmitters and receivers in top row with counting chain and transistor registry below

frequency on some future scan. The associated registry relay is energised in one condition of the bistable circuit and released in the other.

At the end of the scanning cycle a reset stage at each end of the system causes frequencies *f*1 and *f*2 to be transmitted together from the control centre, and frequencies *f*3 and *f*4 from the outstation. Reception of each pair of frequencies simultaneously is detected by "and" gates at the two points, the resultant pulse from each gate resetting the local counting chain. Either the control centre or the outstation is capable of resetting its own and the remote counting chain, so that failure of either reset

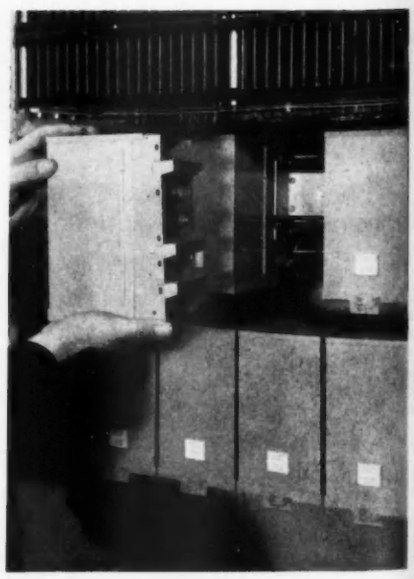


Fig. 3—Part of the relay registry through which the outstation functions are controlled

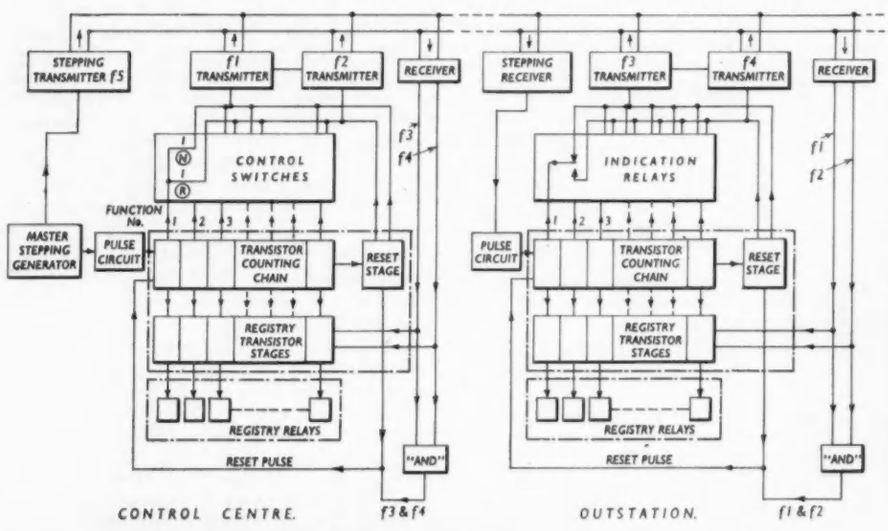


Fig. 1—Elements of transistor-operated continuous scanning and control system

circuit does not cause the whole system to become inoperative.

In the railway signalling installations of this equipment to date the rate of working is approximately 150 controls per second. In each case one remote " Westronic " equipment is controlled over a pair of line wires from the main signalbox. It is stated that there would be no technical difficulty in performing 500 controls in a second by this system, this time allowing for the final registry relays to release or operate.

All the coding is carried out by transistors. The transistors and other components used on each step of the code are identical and are mounted on plug-in printed circuit boards (Fig. 2). Plug-in mountings are used also for the registry relays as seen in Fig. 3. These relays are of the kind known as " stick " relays in railway signalling practice. They remain in the state to which they have been operated by the registry stages until a definite signal is received to reverse their contacts.

As applied to railway signalling " Westronic " installations, by adding remotely-controlled locations to the enlarged areas controlled direct from three new power signalboxes, have contributed to the elimination of twenty-eight manual boxes between Crewe and Manchester. In the London area an interlocking at Clapton has been brought under the control of Hackney Downs, and in Essex the new station at Harlow Town is controlled from Harlow Mill, the latter site being preferred for the signalbox because of shunting operations which need the supervision of signalmen.

High Purity Nitrogen Plant

THERE is a demand from many industries for moderate quantities of pure nitrogen, to be used for blanketing vessels, purging, and many other purposes, which are large enough to render uneconomical the transport from a distance of compressed gas in bottles or of liquid nitrogen in tanks. On the other hand, however, the conventional methods of producing nitrogen on site are not always satisfactory or economical.

In plants based on the combustion of fuels and the subsequent purification of the flue gases it is difficult to guarantee a purity of 99·9 per cent and over. Furthermore, normal double-column air separation plants, using high-pressure multi-stage compressors and reciprocating expanders, deliver nitrogen at atmospheric pressure, and if the nitrogen has to be recompressed it may easily be contaminated.

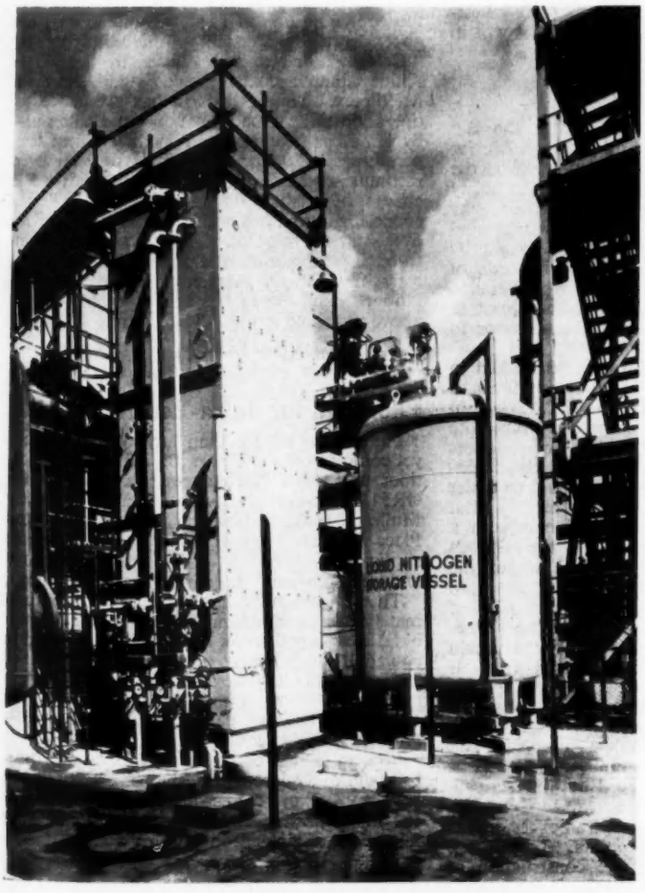
When the U.K. Atomic Energy Authority needed a supply of high purity nitrogen at an elevated pressure, Petrocarbon Developments, Ltd., decided to develop new fully automatic plants based on the experience gained with their earlier work on the use of expansion turbines in connection with oxygen and argon plants and the distillation of hydrogen for the separation of deuterium.

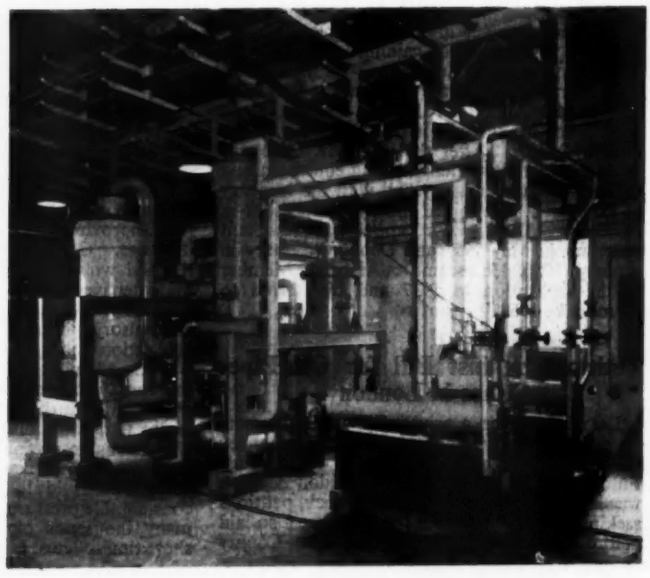
The new plant, of which we include two illustrations, is simple to start up and requires virtually no operator's attention : it has been in successful operation over an extended period.

The high-purity nitrogen is produced by the fractionation of air at low temperatures in a single column operating at 100 lb. per square inch, and is delivered direct to the consumer at this pressure; thus compression of the product, with consequent risk of contamination, is unnecessary. The purity of the nitrogen is normally 99·99 per cent, but still purer gas can be supplied. The air is compressed to 110 lb per square inch and passes through the purification system and the heat exchangers directly to the column without expansion. The low temperatures are maintained by expanding a part of the compressed air, after its passage through the column, in a turbine rotating on air bearings at 60,000 r.p.m.

The capacities of the present series range from 4000 to 40,000 cubic feet per hour of nitrogen. The output of a plant varies automatically with demand from zero to the upper limit, and power consumption is reduced when the offtake diminishes. If no nitrogen is consumed the plant will " tick over " with a minimum consumption of power and will automatically come on stream again when consumption is resumed. For emergency storage and to cover short periods of peak demand, up to 10 per cent of the product can be delivered as liquid and is then passed to a large vacuum-powder insulated storage tank. If then the momentary demand for gas exceeds the productive capacity of the plant, and if, as a result, the pressure in the user's supply line tends to fall, liquid nitrogen is automatically discharged from the tank and vaporised, restoring the pressure to normal and permitting an increased offtake as long as liquid remains in the tank. Should the purity of the product fall below the desired value, production ceases automatically, thus preventing impure nitrogen from entering the user's supply line. The plant then runs on total reflux until the purity is restored, after which production is automatically resumed.

The consumption of utilities per unit of product nitrogen varies with the capacity of the plant and with the degree of purity required. For a unit delivering 12,000 cubic feet per hour, the power consumption is approximately 120kW and the cost of the nitrogen, excluding liquid storage facilities, is found to be about 2/5d. per thousand cubic feet, inclusive of depreciation and reasonable maintenance charges.





Air drying system

(Left)—Cold box and liquid nitrogen storage vessel

SHORTER REPORTS

Education for Management

LAST March, Sir David Eccles, Minister for Education, announced that he intended to set up a United Kingdom Advisory Council on Education for Management. At the same time he announced that there were to be new post-graduate courses in Management Studies leading to a Diploma which would start next September. Last Friday, in a written answer to a Parliamentary question he announced the composition of the new Council. It is to be under the chairmanship of Mr. J. W. Platt, a director of the Shell Transport and Trading Company, Ltd., and formerly Managing Director of the Royal Dutch Shell Group. It will include six members, including the chairman, nominated by the Minister, sixteen members representing professional institutions, industrial organisations, &c., and ten representatives of educational institutions. The chief responsibility of the Council will be to keep under review the provision for management education in the technical colleges, to maintain contact with other bodies providing management education, and to be available to give advice to those other bodies on request.

Secretaryship of the I.Mech.E.

THE Council of the Institution of Mechanical Engineers announces that the Secretary, Mr. Brian G. Robbins, M.Sc.(Eng.), F.C.G.I., M.I.Mech.E., recently expressed a wish to retire before reaching the normal retiring age, and they have accepted his resignation with regret. The Council has appointed Mr. Kenneth H. Platt, M.B.E., B.Sc., M.I.Mech.E., to succeed Mr. Robbins on June 1, 1961. Mr. Robbins was appointed Secretary on January 19, 1951.

Mr. Platt, who is at present Deputy Secretary of the Institution, was educated at Shrewsbury School and the University of Glasgow, where he graduated B.Sc. with First Class Honours in Mechanical Engineering. After receiving his practical training and gaining experience in industry, he became a lecturer in mechanical engineering. During the last war he served in the R.A.O.C. and R.E.M.E., being made M.B.E. for his services in Malta, and held the rank of Major. After the war, Mr. Platt was again associated with engineering education and training, both in industry and with the Ministry of Education. He joined the Institution staff in November, 1952, was appointed Assistant Secretary in May 1953 and Deputy Secretary in January, 1956. He became an Associate Member of the Institution in 1937 and transferred to Member in 1953.

Petitions against Bill for Oil Pipe-Lines in London

LAST November, a private Bill seeking powers to construct a pipeline system from Canvey Island to Denham, with spurs to Purfleet, Fulham and Wandsworth, and London Airport, was laid before Parliament. Last week, petitions seeking drastic changes in the Bill were also laid before Parliament by the London County Council and by fourteen other local authorities in whose areas the pipeline would be operated. The aims of the Bill and the gist of the L.C.C.'s objections to it are summarised hereunder.

THE PROPOSALS

The Bill is sponsored by Trunk Pipelines, Ltd., and seeks authority to build pipelines from Canvey Island to the places enumerated above, the system to be operated as a common carrier and therefore available to all users, according to charges in a published tariff.

The route from Canvey Island to Denham has necessitated the co-operation of only three main authorities, the promoters state, i.e. the North Thames Gas Board for the length from Canvey to Beckton, the London County Council for that section along the Beckton outfall sewer, and the British Transport Commission for the remainder of the route and the spurs. This route not only takes the line through the centre of London, it is stated, but, throughout its length, avoids, to the maximum degree possible, inconvenience to private land owners. Thus it would utilise sections of the routes of gas mains, the Northern Outfall sewer, railways and canals, with one length in tunnel.

It is envisaged that the system will, later, be extended northwards to the Mersey via Birmingham. This route has been surveyed and if this line can be laid it will follow, for almost its entire length, the British waterways canal system. Agreement in principle has been reached with the British Transport Commission for the use of their wayleaves along the first section of the route, but negotiations have not been completed in the extension northwards from Denham.

The system is mainly designed for the transport of white oils, but can be used to carry liquefied petroleum gases and other pumpable substances. Trunk Pipelines, Ltd., states that in promoting this Bill, it has taken note of the example of common carrier pipeline systems in other countries, with the aim of reducing transport costs and making available to concerns which could not economically build separate lines the advantage of pipeline transport.

The promoters of Trunk Pipelines, Ltd., have also incorporated a company called Queen's Channel Terminals, Ltd., for the construction of a deep water marine terminal in the Thames Estuary. This terminal is designed to accommodate tankers of any size and would be equipped to give a rapid discharge rate of crude. The terminal is planned to be connected with the shore and receiving points by submarine pipeline. Trunk Pipelines, Ltd., is at present a consortium of finance, consultancy and construction interests, headed by Close Brothers, the City investment bankers, and it is intended that it will in due course become a public company.

THE OBJECTIONS

The L.C.C. in its petition against the Bill points out that it is the authority responsible for licensing the keeping of petroleum spirit, the fire authority and the local planning authority for much of the proposed route and has authority for improving streets and for sewerage and drainage. Compulsory purchase as sought by the Bill would be injurious to the interests of the ratepayers, it is held, and it is questioned whether a local authority should be subject to compulsory powers of a private concern or to arbitration rulings.

Some 19 miles of pipelines would be laid in the county, constituting a very serious fire and explosion hazard, and whilst the L.C.C. did not doubt that the promoting company would take all reasonable precautions, it has grave doubts that the risk of leakage could be entirely eliminated. The liquids in the pipeline would be under considerable pressure, and in the event of a fault many thousands of gallons could escape in a short time. Thus, however efficient the methods of detection and control, the L.C.C. argues, the liquid in the pipeline would find its way into canals, sewers, &c., and into the basements of buildings. A wide area could, in a short time, become heavily contaminated; if the liquid were petroleum spirit it would not disperse. If the pipeline is built, the L.C.C. goes on, specific requirements for the design and construction of the pipes should be inserted in the Bill. A uniform standard should be adopted, and nationally determined minimum safety standards and the liquids to be conveyed both prescribed. Road improvements may be impeded by the pipeline, it is asserted, and traffic conditions worsened near its terminal points. To sum up, the L.C.C. considers that the construction of oil pipelines on a national scale presents serious problems to public authorities (a position which the Government has acknowledged, in the L.C.C.'s view, by its decision to institute an inquiry), and the promoters should be put to strict proof that the powers they seek are in the public interest.

Recent Rocket Flights

ON Tuesday last week the life support systems of a McDonnell "Mercury" capsule were tested in practice for the first time when a capsule containing a chimpanzee, "Mr. Ham," was boosted by a "Redstone" rocket in a 420 mile trajectory over the Atlantic from Cape Canaveral.

On Wednesday last week the first firing of a "Minuteman" I.C.B.M. took place, also at Cape Canaveral; all three stages were activated and a "target" 4000 miles distant was approached. The launching was from the surface and not from a silo. The principal characteristic of the solid-propellant "Minuteman" is, as the name indicates, an ability to remain for extended periods at exceedingly short readiness, so that it promises a radical reduction in the support costs of a deterrent.

On Saturday last there was placed in a low orbit of 146 to 205 miles height a "Sputnik" of 6½ tons mass. No details of its construction or mission appear to be available, but the closeness of the orbit suggests that experiments in re-entry, possibly with the use of high impulse retro-rockets, are envisaged.

Fire-Resistant Alarm

ELECTRICALLY-OPERATED fire alarm bells or sirens are liable not to work in the event of fire because a failure of the electricity supply has resulted from either the cause or the effect of the conflagration. This disadvantage does not apply to a compressed-gas-driven alarm, the "Colarm," that is now offered by the Walter Kidde Company, Ltd., Belvue Road, Northolt, Middlesex. The new alarm has two modes of operation; it can be turned on—and off again—by hand, or it starts itself in an ambient temperature of 120 deg. Fah. (it is not, however, recommended as a fire detector). With a 5 lb charge of carbon dioxide a "Colarm" will sound for 1½ minutes and with a 10 lb charge for over three minutes. Alternatively, alarms throughout the building can be fed from a single reservoir as in the manner of an electric installation. Each alarm has an output 100–120 dB above threshold in the 1–3 kc/s range.

[Reply Card No. E2145]

Photocell for Infra-Red Applications

HIGHER detectivity than any other photocell yet commercially available for infra-red applications up to five micrometres is claimed for the ORP13 photoconductive cell announced by Mullard, Ltd., Mullard House, Torrington Place, London, W.1. The ORP13 is intended for applications involving infra-red spectroscopy and research into the properties of materials.

The cell, which has a sensitive area of approximately 3 square millimetres of indium antimonide, is attached to its own Dewar flask and is cooled by liquid nitrogen to a temperature of 77 deg. K (−196 deg. Cent.). This cooling system enables very good noise figures to be obtained. The cell can be used for forty-five minutes without refilling the flask.

Spectral range of the ORP13 is from visible to about 5·4 micrometres, the peak occurring at between 4·5 and 5 micrometres. Its sensitivity to monochromatic radiation is 15mV per microwatt of incident radiation.

[Reply Card No. E2146]

Manufacturers' Statement on Railway Modernisation

THE following joint statement was issued by the British Electrical and Allied Manufacturers' Association and the Locomotive and Allied Manufacturers' Association of Great Britain, commenting on the Government's announcement on the railways in the House of Commons on January 30 :

"The railway equipment industry welcomes the green light on the London Midland electrification scheme and the Government's expression of confidence in the British manufacturing industry which will give impetus to the all-important export trade. The manufacturers and contractors fully support the British Transport Commission's estimate that the scheme can be completed by 1966 and the technical, manufacturing and constructional resources are available to achieve this target.

"The industry is however disturbed that despite several months' consideration the Government is still unable to give a clear indication of future policy regarding the modernisation programme as a whole. There is still no authorised capital investment beyond 1961, for which the authorised expenditure is already committed by existing orders. In order to use the resources of British industry to best advantage a long-term investment programme is essential. By its very nature railway equipment production has to be planned well ahead. The manufacturers therefore urge on the Government the necessity for giving early authorisation to the further modernisation proposals which are essential to secure the full benefits of improved services and increased traffic."

Mersey Crossing Proposals

A COMPREHENSIVE report on various bridge and tunnel proposals for the Mersey is to be discussed by the various local authorities concerned, on February 16, at Liverpool. A traffic survey is included in the report which indicates that two additional traffic lanes are already required to relieve congestion in the peak hours. These would be inadequate by 1963 and even four additional lanes would only relieve congestion until 1967–70. The best site for a new river crossing is a little south of the present Queensway Tunnel, the report states. Two additional crossings, however, one north and the other south, would equally satisfy the distribution of traffic and would relieve congestion for a more reasonable period, i.e until about 1976, but at greater cost. The traffic survey has been carried out by Messrs. W. S. Atkins and Partners, for the main consulting engineers responsible for the report, Messrs. Mott, Hay and Anderson.

Eight alternative schemes for a new crossing have been considered in detail, viz. six tunnel and two bridge schemes. These schemes include three for connecting Wallasey with Liverpool, the approach on the Wallasey side using the Seacome Railway as access, and three alternative sites for portals in Liverpool, at King Edward Street, Marybone, and Canning Place.

Connecting of the branch tunnels of the existing Queensway Tunnel is considered in the report.

The report gives details of two other tunnel schemes for connecting Liverpool (Canning Place) and Birkenhead, where there are two alternative portals. One of these is at Chapel Street between Cleveland Street and Price Street, and the other west of Chester Street with a connection to Clifton Square at Birkenhead Central Station.

One of the bridge schemes provides for a connection with a high-level long-span suspension bridge between Liverpool (Upper Parliament Street) and Birkenhead (Victoria Park). Its overall length, it is reported, would be 7750ft, its central span about 4500ft. The other bridge, which is of similar design, is planned to connect Dingle with Rock Ferry.

The report discusses these alternatives and includes twenty-six drawings giving details of the schemes including the approaches to them. The estimated cost of each proposal is also given. The consulting engineers recommend the construction of the six-lane bridge between Liverpool, Upper Parliament Street, and Birkenhead, Victoria Park. With the cost of the approaches and property, the estimated cost of this scheme is about £27,000,000.

Intrinsically Safe Earth-Proving Equipment

WE illustrate an intrinsically safe transformer/relay unit produced by The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. One of its main uses is to ensure proper earthing during operations in which static electricity could be a danger, for example, filling or emptying a road petrol tanker. It will be recalled that under the Petroleum Spirit (Conveyance by Road) Regulations of 1957 the accumulation of a dangerous static charge must be prevented, which means that the vehicle and loading arm have to be earthed effectively.

The transformer/relay unit has a flameproof enclosure with incoming and outgoing terminal

Intrinsically safe transformer relay unit designed to ensure proper earthing as a safeguard against the dangers of static electricity

chambers, the main enclosure housing a certified intrinsically safe transformer and relay. For use as an earth proving device, one side of the secondary output from the transformer is connected to earth, and the other side is connected via the operating coil of the relay to a trailing cable clipped to the vehicle. The secondary circuit is thus complete only when the normal earthing cable of the vehicle is securely bonded to earth. A contact on the relay which closes only if the earth continuity is satisfactory may be used to control an indicator lamp, or the operating coil of a pump motor starter, or a solenoid valve controlling the flow of fuel, or any other equipment which must operate only when the vehicle is properly earthed.

One installation of G.E.C. earth-proving equipment is at the Hythe Bulk Plant of the Esso Petroleum Company, Ltd. Here each bay is equipped with its own unit mounted on the gantry structure. This particular system uses two trailing leads, one of which is at earth potential, and one insulated from earth. The circuit is arranged so that when both leads are connected to the metal structure of the road tanker, a circulating current flows which operates the relay. This in turn provides a supply to the electrical side of an air-operated valve. At the same time, remote indication of the operation of the valve is given in the Plant Control Room. This interlock arrangement therefore ensures that the product cannot flow until the vehicle has been effectively earthed by the operator.

[Reply Card No. E2153]

Birmingham-Preston Motorway

CONTRACTS for building a further 26 miles of the Birmingham-Preston motorway (M.6) between Warrington and Preston, have been let. Tenders submitted jointly by Sir Alfred McAlpine and Sons, Ltd., and Leonard Fairclough, Ltd., amounting to £14,614,969, have been accepted. The work will be carried out under two contracts and is to be completed in twenty-eight months.

This is the length of M6 which was originally put out to tender early in 1960 (see THE ENGINEER, October 14 last, page 641), but the Ministry re-invited tenders because the average cost per mile in the lowest tenders proved higher than for sections of motorway elsewhere. It was therefore arranged that a review of the contract documents was to be carried out to see if savings could be made without departing from the basic specifications. The cost as now given in the figures above is £562,000 per mile, which is appreciably higher than corresponding figures for other schemes. The reasons given for this are as follows : (i) the unusually moist soil conditions in this part of Lancashire ; (ii) provisions against mining subsidence along that part of the route in a mining area ; (iii) more costly drainage arrangements in the length of road which passes through a "semi-urban" area ; and (iv) the high number of bridges per mile. Even so, economies are stated to have been made in the review due to (i) changes in vertical alignment, drainage and earthworks ; (ii) reduction of provisional items in the bills ; and (iii) the use of more excavation than originally as fill in the embankments, and hence less call for importing fill. The Ministry does not state the magnitude of the economy achieved in the re-tender, nor whether the two firms named were the lowest tenderers in both cases. The difficult soil conditions and the Lancashire weather were factors which led to stipulating a twenty-eight-month period of construction.

The route of the section now to be constructed starts at the northern end of the Thelwall Viaduct. The viaduct is already under construction and will carry the motorway from Cheshire over the Manchester Ship Canal and the River Mersey. From this point, it passes northwards, to the west of Wigan and Chorley, and joins the southern end of the Preston By-pass at Bamber Bridge. The viaduct at Gathurst over the River Douglas, north-west of Wigan, is being built under a separate contract and work on it is already well advanced.

The motorway will have two 36ft three-lane carriageways, each with a 10ft wide hard shoulder and separated by a 15ft wide central reserve. The construction of seventy-two bridges will be necessary, in addition to a railway bridge at North Ashton, which is being built by the British Transport Commission. There will be eight junctions with the existing road system plus a spur road to A.49 constructed under a separate contract. The works have been designed for the Ministry of Transport by the agent authority Lancashire County Council, for whom the county surveyor and bridgemaster is Mr. James Drake, M.I.C.E.

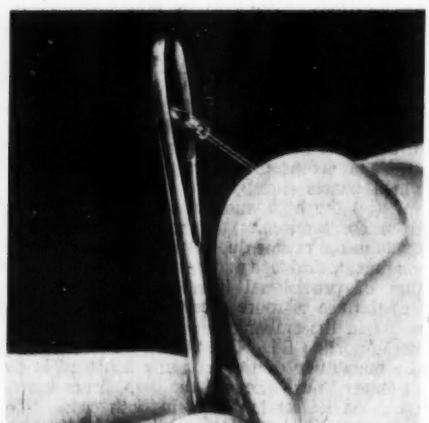
The whole 78 miles of motorway between Dunston, north of Birmingham, and Preston will soon be under construction. The length in Staffordshire is already in hand. The next section to be started, after the Lancashire section, will be the 15 mile length in North Cheshire, between the A.54 route at Holmes Chapel and the A.56 at Thelwall, for which tenders were invited in December. Tenders for the last section, the 10 miles in South Cheshire between the A.54 and the Staffordshire boundary, will be invited shortly.

SHORTER REPORTS *(continued)*

"Microminiature" Lamp

A NEW "microminiature" incandescent metal filament lamp, only 0·055in in diameter and 0·175in long, is being marketed by the Special Products Division of Thorn Electrical Industries, Ltd., Great Cambridge Road, Enfield, Middlesex. This lamp (known as the "Mite-T-Lite") provides specialists in the field of "microminiaturisation" with a compatible light source which may be used for a wide variety of applications such as photo-electric logic systems, medical equipment, high-speed punch card and tape readout devices, compact matrix displays, airborne electric equipment, commercial displays and push-button lighting.

The filament is made from tungsten wire of 0·00025in diameter, wound in a coil of forty turns, and the lamp is designed to operate between 1·0V and 1·5V with a design mean of 1·3V. Its cold resistance is 6·5 ohms minimum and hot resistance 38·0 ohms minimum at a 35mA. The lamp current is only 30mA maximum at 1·3V d.c. which permits direct operation



"Microminiature" tungsten filament lamp, 0·055in diameter and 0·175in long. Voltage range 1V to 1·5V, light output 45 to 50 millilumens at 1·5V

from a transistor. Operating at 1·3V d.c. the life expectancy is approximately 2000 hours. The light output is 45 to 50 millilumens at 1·5V d.c., which is sufficiently strong to be seen in normal room lighting.

Because it has a small filament with an extremely low thermal inertia this new lamp has an unusual, but significant, modulation capability. Light output will follow voltage impulses up to 100 pulses per second. Modulation of decreasing maximum-minimum range, however, continues well above this frequency.

[Reply Card No. E2161]

Rock-Ripping

A DEMONSTRATION of rock-ripping at the Merehead Quarry (near Shepton Mallet) of Foster Yoeman, Ltd., was held recently; it was organised by Bowmaker (Plant), Ltd. The machines demonstrated were Caterpillar D9 tractors fitted with power-operated gear shift and with hydraulically-operated bulldozers and Caterpillar and Kelley hydraulic rippers. The application was ripping in limestone bedrock and it was claimed to be the first time in this country that tandem ripping had been demonstrated to the quarry industry. Over the last four years, the Caterpillar Tractor Company has developed techniques which, the company claims, ensure that all rock will rip when suitable equipment is applied. A refraction seismograph is used to measure the overall consolidation of surface materials, and hence deduce the plant needed for the job. The principle utilised is that seismic waves travel through subsurface materials at varying velocities depending on their degree of consolidation; they could vary from 20,000ft per second in a tight hard rock formation to less than 1000ft per second in a loose loamy soil.

When ripping, the tractor lowers the ripper into the rock to the depth it is able to maintain in the hardest areas. The tooth is lifted clear, the tractor turns, starts another run until the area has been ripped and then repeats the process. The ripped rock is either dozed over the face, dozed to stock, or picked up direct by loading machine or scraper. A 3in pad of ripped material is left to provide traction on the next ripping phase and to cushion the tractor.

Production rates in excess of 200 bank yards an hour are quoted. For the two D.9 tractors working single and in tandem the down pressure is quoted as 40,000 lb and 80,000 lb respectively, and the tractive force available as 104,000 lb and 208,000 lb respectively.

Inspection of the stone revealed some slightly crystalline parts with the presence of some chert. There was one area too dense for single ripping and one or two knobs resistant to tandem ripping. The crushing strength of the stone varied from 27,000 lb to over 30,000 lb per square inch. When the seismic test was made, there was evidence of some fissures and faults. The velocity in the carboniferous limestone was 5400ft per second, and varied from 5000ft per second to 5400ft per second in this area.

[Reply Card No. E2162]

N.E.M.—Gotaverken Engine

THE first Gotaverken diesel engine to be built in this country has completed, successfully, test bed trials at the works of The North Eastern Marine Engineering Company, Ltd., Wallsend, Northumberland. The work of installing the engine is now proceeding, the ship concerned being the cargo ship "Montrose," of 8590 tons deadweight, which Bartram and Sons, Ltd., are building at Sunderland for Buries Markes, Ltd. This engine is a two-stroke, single-acting unit with uniflow scavenging and is turbo-charged on the constant pressure system. There are five cylinders of 760mm bore by 1560 mm stroke and the continuous rating is 6300 b.h.p. at 112 r.p.m. Napier turbo-chargers are fitted and the engine weighs 290 tons complete. Ship trials are expected to take place in March.

[Reply Card No. E2163]

Instrument Manufacturers' Publication

THIS year the Scientific Instrument Manufacturers' Association of Great Britain (SIMA) has replaced its former *SIMA Bulletin* with a larger publication entitled *SIMA Review*. The new journal will appear twice a year and its first number is dated January. One of the reasons for the change is that the former two-monthly publication was often covering events and products which had been dealt with some time before in the daily, weekly and monthly papers as a result of the flow of information from the industry to the press. The new review, states the President of SIMA, Mr. G. C. Ottway, "will contain informative articles reflecting the activities and interests of the British scientific industry and will be of interest to a vastly wider reading public and thus help to build up the prestige of the industry itself, not only at home but abroad." Two contributors in the January issue discuss the importance of information services for the press. In one of these Mr. F. W. Dawe, Managing Director of Dawe Instruments, Ltd., urges a careful consideration of advantages and disadvantages when deciding on the publication of technical material, and reminds readers that "manufacturers in other countries are much more liberal in the exchange and publication of information than we are." Other articles are in the form of general reviews of activities, policy and practice rather than descriptive of specific apparatus. Copies of the review are obtainable, price 7s. 6d., from the Scientific Manufacturers' Association of Great Britain, 20, Queen Anne Street, London, W.1.

Electronic Equipment Exports

STATEMENTS issued by the Electronic Engineering Association in connection with the publication on February 2 of its annual review, *British Electronic Engineering*, show that last year exports of electronic equipment totalled about £28,000,000, or some five times more than ten years ago. Estimated gross output of the capital goods side of the electronic industry was about £175 million, representing a growth of more than two-and-a-half times in ten years. Commonwealth countries took communication, navigational aid and radar equipment to the value of £5,027,443 in the first nine months of last year, and total world exports in this field for the same period were £12,980,163. In these two categories the largest purchasers were, respectively, Canada (£1,347,814) and West Germany (£848,204). The annual review forms an illustrated survey of achievements at home and abroad in communications, aviation, marine, television and sound broadcasting, industry, defence, instrumentation, nucleonics and data processing. The Chairman, Mr. L. T. Hinton, draws special attention to progress with the "Autoland" blind landing system, and the aviation section of the review mentions the continuing development now centred on using a sufficiently narrow beamed and accurate ILS system to replace the use of leader cables to line up the aircraft with the runway in the final approach. Among new items which have arisen since the review went to press is the fact that the telephone service of the Irish Republic is being strengthened by 240-channel, 7400Mc/s microwave links between Waterford, Wexford and Inniscorthy.

Pipe Weights and Strength Calculator

INCREASING use is being made of slide rule calculators for scientific purposes throughout industry, and the latest special application slide rule to be made available is the "Pipe Weights and Strengths" calculator. This has been designed by Mr. I. Alexander, of Intercontinental Enterprises, and produced by Blundell Rules, Ltd. Answers to three commonly recurring sets of routine calculations, which normally take some considerable time to work out, can be obtained in a few seconds with the aid of this highly accurate instrument. The answers can read simultaneously in British and metric units. One operation gives the weight of steel, aluminium, cast or spun iron, bronze, copper or lead pipes when the diameter and thickness are known. A second operation determines the value of either the bursting, test or working pressure; the yield or stress point of the material; or the O.D. or thickness of any metal pipe when the other three values are known. Finally a set of scales gives the relative carrying capacities of pipes of different internal diameters, while it is possible to use the rule for straightforward price calculations.

[Reply Card No. E2166]

Automatic Level Crossing Barriers

THE first fully-automatic level crossing barriers in this country were brought into operation at Spath, near Uttoxeter, on February 6. At Spath crossing the B5030 road from the Ashbourne direction crosses the line of the London Midland Region from Derby to Rocester. The installation comprises two lifting half-barriers, each covering the left-hand side of the road when lowered, and a combination of red flashing lights, gongs and illuminated signs for warning road users of approaching trains. No railway signals are associated directly with the protection of the crossing, but "whistle" signs are located on each approach. The line is double-track. Powers were given to the Minister of Transport in the British Transport Commission Act of 1957 to authorise safety arrangements such as these at public crossings with automatic or remotely-operated barriers.

The barriers are normally latched in the raised position. When an approaching train occupies a track circuit 462 yards from the crossing on either side, pairs of warning lights on the barrier pivot posts begin to flash and two-tone gongs to sound. Eight seconds later, under the control of timing relays, the latches are released and the barriers, which are pivoted off-centre, descend by gravity under the restraint of counterweights, this operation taking a further eight seconds. At the same time two steady red lights on each barrier, one at the centre and one at the tip, are illuminated. Maximum speed on this section of line is 45 m.p.h., which allows five seconds between the barriers being fully lowered and the arrival of the fastest train. The gongs stop sounding when the barriers are fully down, but the steady and flashing lights remain in operation. The lamps in each flashing pair light alternately to give the arresting impression of a swinging red light.

Immediately after the crossing the train actuates a mercury rail treadle. If no train is approaching from the opposite direction, the motors which raise the barriers are then energised and the relay of the approach track circuit, which has remained operated after the track circuit has been cleared by the train, is released. The roadside lights continue flashing until the barriers are 10 deg. above the horizontal, but the steady lights remain on until they are nearly vertical.

There is a further track circuit 640 yards from the crossing on each approach. If this is occupied by a train when the barriers have been lowered by a train from the opposite direction, "second train coming" signs are illuminated at the crossing and the barriers remain down until this second train has passed the crossing and operated the treadle on its track. The treadles are of the mercury pattern made by S.G.E. Signals, Ltd., which are operated by the deflection of the rail under the train. They were chosen to control the release because they are not liable to unauthorised interference in the same way as a track circuit. Any such experiments on the approach tracks would only result in the "fail safe" condition of lowering the barriers. This, however, is relatively unlikely to happen since the track circuits are too far from the crossing for the author of the mischief to enjoy the spectacle.

The barrier equipment, power supply and relays were supplied by the Westinghouse Brake and Signal Company, Ltd. A "Westat" constant potential power unit provides 24V d.c. for the barrier motors and relay operation and trickle charges a battery, which takes over operation of the motors, lights and signs in the event of a mains failure. This apparatus, together with a plug-in relay rack, is housed in a hut adjacent to the crossing. Two of the track relays are in the hut, but the remainder are external and operate through repeater relays.

Remote indication of the working of the barriers is given by a needle instrument in Uttoxeter North signalbox, together with a "power off" warning. Supplies for these purposes are taken from a Heayberd rectifier unit. Telephone communication is provided between the crossing and the signalbox for road users to notify the signalman in case of undue delay in raising the barriers. The two-tone gongs were supplied by Alfred Archer, Ltd., Halifax.

The whole installation has been carried out to the requirements of the Minister of Transport and Mr. S. H. Gould, operating officer, London Midland Region, under the direction of Mr. E. G. Brentnall, chief signal and telecommunications engineer, London Midland Region. The latter was a member of the party of officers who visited the Continent to report on the latest practices in level crossing protection.

Spath crossing, showing barriers lowered, flashing signal, and rear of "second train coming" sign

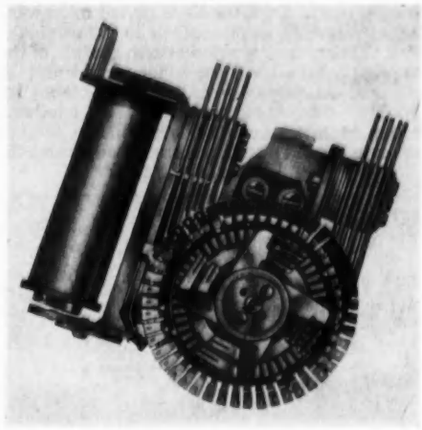
Film on High-Speed Flight

FOLLOWING its production of a series of three films on high-speed flight, intended principally for students of aeronautics, the Shell Film Unit has made a simplified version which should appeal to a much wider audience. It is available in both 16mm and 35mm gauges. The film, which deals with the behaviour of air at speeds approaching, around, and beyond that of sound, assumes no technical knowledge beyond the meaning of "lift" and "drag." It opens with an explanation of how sound travels through air and of what is meant by the speed of sound, and goes on to define the term Mach Number. From this it proceeds to a consideration of air flow in the three speed ranges mentioned and shows, by wind tunnel experiments and animated diagrams, the adverse effects on aircraft, and how designers can overcome them. The film is in colour, and strikingly effective use is made of the Schlieren technique in showing air flow about model wings and aircraft at different speeds.

From a consideration of existing designs the film proceeds to examine some of the problems likely to be encountered in the design of aircraft for performances not yet attempted, and concludes with a forecast of some of the wing and fuselage shapes which will probably be necessary in the future.

Combined Stepping Relay Rotary Switch

A NEW combined stepping relay, rotary switch and relay has been introduced by the Special Products Division of Thorn Electrical Industries, Great Cambridge Road, Enfield, Midlesex. This "three-in-one" rotary stepping relay (illustrated here) is a combination of (1) a standard relay with a knife-edge armature pivot operating contact springs, and a ratchet and pawl-driven stepping mechanism; (2) a ratchet-driven rotary switch consisting of four banks of twelve points each with sliding bifurcated spring wipers, and (3) a ratchet-driven stepping relay with two cams which open and close double contact type springs in accordance with the cam pattern. In automation, counting and tallying operations, this relay has many applications, and will be useful for automatic test equipment requiring programming, sequencing, or memory storage. Relatively low power consumption makes it suitable for remote control and telemetering.



Combined stepping relay, rotary switch and standard electromagnetic relay

The rotary switch terminals are arranged in a circular pattern with four banks of twelve points each; each bank comprises a quadrant of the circle and contains a common bus which is connected to the twelve isolated points in sequence by means of a sliding wiper as the switch is operated. The four bifurcated sliding wipers are made of phosphor bronze and the wiper contact assemblies are insulated electrically from each other. The contacts of the rotary switch bank are capable of carrying 0·5A on a steady state basis and of interrupting 0·1A at 50V d.c. with a resistive load. The ratchet-driven stepping relay has two circular cams sharing space on a common shaft which actuates the rotary switch wipers. Each of the two cams actuates up to five contact springs in accordance with the predetermined cam pattern. In addition there are two pile-ups with a maximum of four springs each which open and close with every step of the rotary stepping relay switch. All the contact springs are the long leaf spring type with supports to ensure long life and trouble-free operation. The twin noble metal contact points are capable of handling 1·0A steady state and of interrupting 0·5A at 50V d.c. with a resistive load.

Coil voltages are 12V, 24V, 48V and 110V d.c. Two standard coils are available: (1) a high-speed low-inductance coil capable of stepping the switch at a rate of forty steps per second (power requirements 4W); and (2) a more sensitive low-speed inductance coil capable of stepping the switch at a rate of twenty steps per second (power requirement 2W). Life expectancy is 5,000,000 to 6,000,000 operations.

[Reply Card No. E2173]

SHORTER REPORTS *(Continued)*

London Tower for Microwave Links

SINCE the lattice steel mast on the Museum Exchange building in Howland Street, London, W.1, was erected to carry the aerials of the first London–Birmingham radio television link, inaugurated on December 17, 1949, the increasing height of buildings built and planned in the London area has threatened to obstruct earlier line-of-sight transmission paths. The effective height of the Museum Exchange aerials at present is only 180ft. Over the same period microwave links have greatly increased their importance in the Post Office communication system because of the growing demands on the telephone service and the cost and difficulty of providing new cable routes. To-day, also, the transmission of television programmes between studios in different parts of the country and distant transmitters increases the

An impression of the 507ft tower for television and microwave telephony which the Post Office proposes to build at the Museum Telephone Exchange, London

calls on cable capacity. The Post Office therefore plans to build a 507ft tower at the Museum Exchange, off Tottenham Court Road, to carry the aerial systems of existing radio services and those which will be required in future. The design, of which an artists' impression is reproduced, has been prepared by the Chief Architect's Division, Ministry of Works.

The exchange, in addition to being a switching centre for the national radio and television network in the London area, is also a focal point for microwave links, being the London terminal of those to Birmingham, to Norwich and the Eastern Counties, and to Southampton and the Isle of Wight. Proposed new microwave routes would radiate from the tower to Dover and the Continent, and to Bristol and the West. The Dover link would connect with the cross-Channel link to Lille which was inaugurated last year (see our June 3, 1960, issue), enabling Eurovision programmes to be transmitted direct to London on the Continental 625-line or 819-line standards and to be converted to 405 lines there instead of at Tolsford Hill, (Folkestone) as at present.

The original London–Birmingham link, for which the equipment was supplied by The General Electric Company, Ltd., operated on 900 Mc/s. Subsequent development caused the system to be superseded for a time by coaxial cable, but the link has since been reconstructed for working on 2000 Mc/s and is now fully utilised for telephony and television. This restoration of its importance is a symptom of the current pressure on communications facilities, which is likely to increase with the spread of subscriber trunk dialling.

Progress is being made in enlarging the capacity of radio channels, and while 600 telephone circuits per channel has been a usual figure hitherto, it is now possible to handle 1000 circuits. Such a channel could be used alternatively for a television programme, carrying sound and vision signals, and would assist in relieving the cable system, since normal practice up to now has been to allot a microwave channel for vision and a cable link for the sound. Increases in the channel capacity of cables have also been achieved, but sometimes at the expense of closer repeater spacings, the interval in the latest system being 3 miles instead of an average of 7 miles.

Even so, the Postmaster-General has stated that more microwave links will be needed by the end of 1964, leading to the proposal to begin work on the tower this year and complete it by the end of 1963. Any delay in providing new line-of-sight paths to and from this communications centre would compel the Post Office to undertake an underground cable programme, with attendant disruption of traffic in London and on the main roads. Any other site for the tower than the present one would involve heavy work on extending existing cable connections with the microwave links.

The tower will be 507ft high, and about 50ft in diameter, with six aerial floors and fifteen other floors. Two lifts will serve a public observation floor at a height of 463ft. The structure of the tower will be of reinforced concrete. Its upper section (levels 355ft to 470ft) which will house the aerials and public gallery, will have a central r.c. shaft 20ft in diameter. A steel yoke will be built on top of this shaft, and a framework of steel hanging from it will carry the aerials. The hanging framework is described as of "tenuous pattern so as to provide the minimum of interference." It will be possible to dismantle large sections of the aerial floors, and the permanent framing in the outside walls is to be limited to a few positions, to allow flexibility in the transmission services. Lifts and service cables are to be inside the shaft, which will rise a further 35ft to house the lift motors and control gear.

The centre section of the tower (levels 115ft to 355ft) will comprise the apparatus floors. In this section the shaft structure is to be supplemented by a frame of twenty-four columns spaced round the circumference, but with no continuity between the external framing of the top and centre sections.

In the cover section (ground level to 115ft), the central shaft of reinforced concrete is to be increased to 28ft in diameter at the top of the section, and 35ft at the base, with internal stiffening rings. A prestressed concrete diaphragm will be built at the transition from 20ft to 28ft in diameter.

The design envisages a structural connection with the main building 80ft above the ground, where horizontal load due to wind will be transmitted from the tower. The maximum horizontal reaction at this point is to be 500 tons, but vertical deformation of the tower will not be restrained.

The sub-soil consists of water bearing gravel overlying blue clay at a depth of 25ft. The foundation is to be formed in the blue clay with a reinforced concrete square truncated pyramid of hollow box construction, 90ft wide by 22ft high, with prestressed and reinforced concrete bearing panels. The total weight of the tower and its foundation will be 13,000 tons.

Determination of the deflections at the top of a tower such as this one is important, since the performance of the aerials and the directions of the transmitted beams are clearly modified by the deflections. The design computations estimated a deflection of 6in at the top of the tower due to a 70 m.p.h. wind, and up to 2in due to midday summer sun. The maximum permissible lateral deviation of the aerials is given as 20in. The problem of dynamic stability is also being considered ; wind tunnel tests are in progress at the National Physical Laboratory to ensure that no resonance phenomena will arise due to steady winds of moderate strength.

Frigid Test Facility

THE Engine Test Laboratory of Simms Motor Units, at East Finchley, has been supplemented with a cold chamber. The main room is 13ft 5in by 10ft 9in, and is entered by an air lock 8ft by 5ft 9in ; thus a medium-sized car or an engine of up to 300 h.p. can be accommodated. Refrigeration plant supplied by J. and E. Hall, Ltd., affords temperatures down to −40 with automatic control to $+\frac{1}{2}$ deg. Fah.—to reach this temperature from ambient takes three days. Temperature cycling can be performed under manual control.

The cold test facility is, to the extent that it is not occupied by the owners' testing programme, available on a hiring basis.

[Reply Card No. E2182]

High-Temperature Vacuum Furnace

TEMPERATURES up to about 1500 deg. Cent. can be maintained in the furnace (illustrated here) which has been developed by Goulding

Laboratory vacuum furnace, with tungsten elements, designed to maintain temperatures up to 1500 deg. Cent. in the working zone

and Partners (Consultant Engineers), Ltd., Essex Road, Acton, London, W.3. This equipment was originally designed for laboratory use in connection with sintering and brazing.

This design makes use of the high-temperature

characteristics of tungsten or molybdenum in the form of helical resistance elements. These elements are freely supported from a ring assembly which holds the elements in position without constraining their axial freedom during the heating and cooling cycle.

In this particular furnace a tungsten element assembly produced by Electro Alloys, Ltd., is fitted, to give an effective hot zone approximately 6in in diameter and 6in in length. The tungsten elements are uniformly distributed around the periphery of support rings to ensure uniform distribution of heat. By eliminating ceramic formers (especially in the hot working zone) the possibilities of chemical contamination have been minimised. Although small element guide bushes are required to locate and insulate the element wire they are placed outside the high temperature working zone.

This element assembly is designed for vertical loading but the construction can be adapted for horizontal furnaces when it is necessary to provide one or more hot zones operating at different temperatures. A final water jacketed cooling zone may also be provided if required.

To minimise the heat losses an appropriate number of concentric circumferential and end radiation screens are placed around the hot zone. These screens are supported independently from the element assembly. The resistance heating elements are fed from the low-voltage secondary winding of a variable transformer which may be manually controlled, to enable the energy input to be adjusted in accordance with the resistance of the elements, especially during the heating up period. For accurate control of these manual adjustments a current transformer is included in each of the three-phase heater circuits, the secondary windings of each transformer being connected to appropriate a.c. meters calibrated to read directly in amperes. By relating the setting of the transformer control wheel with the individual phase currents the condition of the elements and the correct balance of each circuit may be accurately ascertained. The control instruments are mounted in the rear instrument panel.

A high-temperature thermocouple or other suitable temperature sensing element is situated in the hot zone and directly connected to a controlling indicator or recording instrument. Once the predetermined temperature has been reached the main controlling circuit is broken, de-energising the three-phase mercury relay and temporarily disconnecting the transformer. If this simple "on-off" control is too coarse for the temperature accuracy required, variations in the circuit would permit elements to be connected in either series or parallel depending upon the heat requirements and the precise nature of the furnace application.

To protect the tungsten elements from oxidation they are operated in vacuum, the furnace assembly being mounted on a baseplate which forms an integral part of the vacuum chamber once the removable water-cooled cover has been placed in position. Vacua in the region of 10^{-5}mm of mercury are obtained, with working temperatures considerably in excess of 1000 deg. Cent., by the use of a standard mechanical backing pump resiliently coupled to an oil diffusion pump which is mounted within the framework and directly below the furnace baseplate. A standard refrigeration trap is fitted between the diffusion pump and the furnace baseplate. To minimise vibration the mechanical backing pump is mounted independently of the main frame, as illustrated. The vacuum is indicated on one of two conventional vacuum gauges on the instrument panel. A "Tensator" motor helps to "balance" the water-cooled stainless steel furnace case, to facilitate the raising and lowering of the covers.

The upper surface of the furnace baseplate is machined to provide one face of the high vacuum seal between it and the cover, and this plate also incorporates water-cooled electrodes which carry the main heater currents for the resistance element circuits. Provision has also been made for additional sealed and insulated electrodes which may be used for thermocouples or other control circuits.

Although some protection for the resistance elements has been achieved by arranging electrical interlocks between the vacuum control and heater circuits, the degree of vacuum at which heaters may be energised is left to the discretion of the operator; but the elements are protected against electrical failure on to the vacuum system.

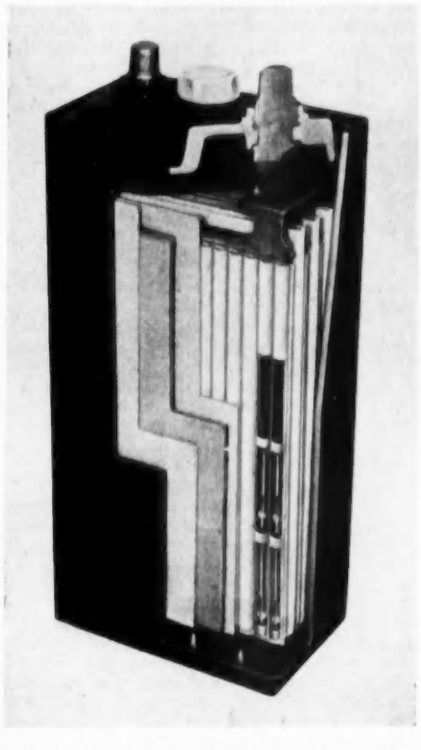
All exterior surfaces are clad in stove enamelled sheet metal panels which are removable for servicing. Although the design of the mechanical and vacuum assembly is regarded as basically standard, the actual furnace unit may be vared considerably to suit individual requirements.

[Reply Card No. E2183]

Traction Batteries

HIGH-CAPACITY tubular batteries for traction introduced by Crompton Parkinson, Ltd., Crompton House, Aldwych, London, W.C.2, are complementary to the company's standard specially-armoured ranges, which are continuing in production. The new batteries give from 32 per cent to 38 per cent increase in capacity over the standard design and have been designed for use where the circumstances call for either high capacity or reduced physical size. In practice, advantage may be taken in two ways of the capacity of these batteries, since either a larger-capacity battery of a size already in use may be installed, thus allowing the running time of a truck to be extended; or a smaller and lighter battery of a given capacity will save room and increase the payload of a vehicle.

In addition to increasing capacity by the use of a tubular positive plate, the armouring of the negative plate has been correspondingly



Sectional view of traction cell showing tubular positive plate and armouring of negative plate

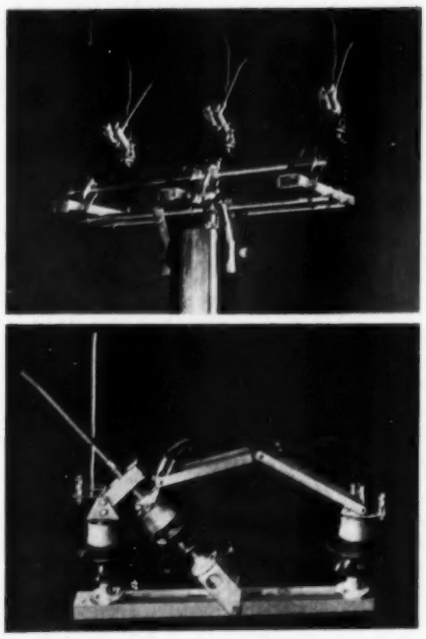
strengthened. In the positive plates the current is carried by vertical spines which are cast integrally with the top connecting bar in a special lead alloy; the active material is held in close contact with these spines by finely-woven fabric tubes. The material of the tubes is a synthetic fibre, immune from attack by sulphuric acid and oxidisation. Its fine weave minimises loss of active material, and it has a high porosity which enables the performance to be maintained even at the highest rate of discharge. An additional feature is the use of a conducting lead alloy base plug. Besides sealing the bottom ends of the tubes this connects the spines electrically and thus provides an alternative current path if a spine should fracture towards the end of the life of the battery.

The negative plate is enclosed in an armoured envelope consisting of two sheets of an inert, microporous synthetic material, joined round three sides by a P.V.C. strip. This strip is bonded to the sheets by a technique which ensures a strong and permanent bond. Thus enclosed, it is impossible for material which may eventually be shed by the plates to accumulate and cause side and bottom shorts. The low-resistance microporous sheets forming the armouring of the negative plate also act as separators: there are thus no loose separators in the battery.

[Reply Card No. E2191]

Torque-Driven 11kV Isolator for Rural Systems

THE torque drive embodied in the new 11kV isolator announced by Switchgear and Equipment, Ltd., Banbury, Oxon, represents a fresh approach to the design of airbreak isolators for rural electrical distribution systems. It is believed that torque drive, with its advantages in simplicity and lower cost, has not previously been fitted to overhead rocking isolators. As illustrated the isolator is offered in two-insulator



(Above) 11kV two-insulator isolator. (Below) One phase assembly of a three insulator isolator

(type TLR2) and three-insulator (TLR3) types, of 400A normal current rating, and the design has been tested to 13·1kA for three seconds throughput at 11kV. There is a choice of four different insulators which, like the contact and arc-horn parts, are readily replaceable. A point of interest about the equipment is that the fixed contact has "U"-shaped jaws which give increased pressure with increased current. The moving contact is cylindrical and can be rotated to present new contact surfaces, thus prolonging its life. Universal supporting steelwork of a new design is part of the complete equipment. This steelwork accepts either the two-insulator or the three-insulator isolator for vertical or horizontal mounting on single or "H"-post structures.

The total cost of the isolator has been reduced by comparison with previous designs, and further savings are claimed because of simplified installation and maintenance procedures. Extensive use is made of British Standard Pipe in the structure and the drive, and all drive connections are made by piercing-screw joints which obviate the necessity for specifying exact lengths of piping when ordering.

[Reply Card No. E2192]

SHORTER REPORTS *(Continued)*

Training Traffic Engineers

THE work of the Graduate School in Highway Engineering, University of Birmingham, formed the subject for discussion at the meeting of the Traffic Engineering Study Group of the Institution of Civil Engineers on January 26. A paper outlining the annual M.Sc. course, which covers both highway and traffic engineering, was presented by F. D. Hobbs, A.M.I.C.E., who holds the lectureship in these subjects sponsored since 1957 by the Worshipful Company of Paviors. Since 1959 the University has had the further benefit of a £140,000 fund (£20,000 p.a. for seven years) contributed by industry, which has enabled the graduate school to be provided with its own separate block among the new buildings of the civil engineering department, of which it forms a part.

Introducing his paper with slides of the accommodation and of designs, road alignments, intersection lay-outs, traffic surveys, and other exercises completed during past courses, Mr. Hobbs spoke highly of his students ; he had great faith in their generation, but Britain lagged far behind other countries in the application of traffic engineering, and would never catch up unless the Government exerted itself in the matter. The numbers attending the course had been no more than : 1957, 3 ; 1958, 10 ; 1959, 23 ; 1960, 23 ; and one-third of the total had been overseas students.

There was high praise for the course throughout the discussion ; criticism commonly took the form of an appeal for more time to be devoted to some particular subject : for instance, more economics, more on the broad philosophy of transportation, more town planning, more on public relations, more on the maintenance and operation of existing roads as opposed to new construction, more on public service passenger transport. To counterbalance these there was only one appeal for less of anything ; it came from a speaker who, while attending a parallel course, had felt that the highway and traffic engineers were being overworked ; he suggested that the pre-eminence of soil mechanics in the syllabus should be reviewed. Mr. Hobbs was able to point out that the syllabus given in the paper had actually been under review since its publication, meeting certain of these criticisms to the limited extent the duration of the course permitted ; he was, naturally, in accord with those who favoured the foreign five-year course, but under the present system it was essential to devote the whole of the three-year undergraduate course to fundamental engineering, leaving only this optional fourth year for specialisation.

Certain of the fieldwork included in the course is carried out in a neighbouring county : a representative of the county surveyor testified that this work is often of lasting value to the county ; he strongly advocated such co-operation with teaching establishments, but he felt that the lessons learned and information gleaned were not always as widely disseminated as they should be in this country. On the subject of sparing highway engineers to attend a year's course, he felt that local authorities could hardly be expected to do more than allow unpaid leave of absence ; but he knew of two candidates who had been financed by university grant and D.S.I.R. grant respectively. Mr. Hobbs mentioned that only overseas applications are plentiful ; it is hoped to take more than twenty-three students in the new accommodation.

Irrespective of the financial problem, another speaker queried whether a university is the correct place to teach traffic engineering : colleges of advanced technology might be more appropriate. He did not rate the subject difficult though it required a tremendous fund of knowledge, which could be obtained by reading ; and, in his experience, the more academic faculties in a university tended to look down on highway and traffic engineering. Again it was possible, he though, that too many universities would take up the subject : what is the extent of the demand for traffic engineers ? To that question no answer was formulated, though one speaker saw traffic engineering growing ultimately into one of the normal public services of all the local authorities in this country.

Two speakers elected to pronounce upon the essentiality of university training in civil and highway engineering for professional traffic engineers (as opposed to technicians) on the lines followed at Birmingham. The first one likened the highway engineer and the traffic engineer to doctor and surgeon, pointing out that it would not do to be operated on by a surgeon without full medical qualifications. The second could not imagine traffic engineering divorced from highway engineering : "all highway engineers should know traffic as they know soils," he said ; his doctrine might be paraphrased as that of "the compleat highway engineer." Against this it had been adumbrated earlier that the difference between a highway engineer and a traffic engineer is the difference between a producer and an operator, which traditionally results in a complete separation of the two careers. And it had been pointed out that in the Army, on active service, the talent of the Royal Engineers is not expended on traffic problems ; movement is a routine function of the Staff, who are all-rounders, not necessarily engineers ; they decide how the available roads and tracks are to be operated and the Provost service sees to it that their decisions are implemented.

The final subject to come under discussion concerned the training of lecturers in traffic engineering. The Road Research Laboratory was able to report that its short courses continue in strong demand ; the diverse attendance includes many lecturers from universities and technical colleges ; there is evidence of a widespread demand for traffic engineering courses of all sorts and at all levels.

Drying Electrical Equipment *in situ*

TRANSPORTABLE apparatus for the *in situ* testing and drying of electrical equipment that may be affected by moisture is available from the Marine Department, Telecommunication Division, of Associated Electrical Industries, Ltd., Woolwich, London, S.E.18. It is known as the E.A.F. equipment and it consists, essentially, of a low-voltage source of supply of drying current which is passed through the circuit whose insulation has been found faulty. The unit (illustrated) contains a voltmeter and ammeter, to indicate the voltage applied and the current flowing during the drying-out process ; a megohmmeter on which the insulation resistance can be continuously monitored ; a resistance thermometer to indicate the temperature of the conductor during drying ; and a thermostat to control the drying temperature so that overheating of the conductor and insulation is avoided. A graph on the top plate of the instrument shows the relationship between the current-carrying capacity of the conductor being treated, the heating effect of the drying current, and the life of the cable under various drying conditions. These curves only apply to long-term overloading of the conductor, as short-term overloading has no serious effect.

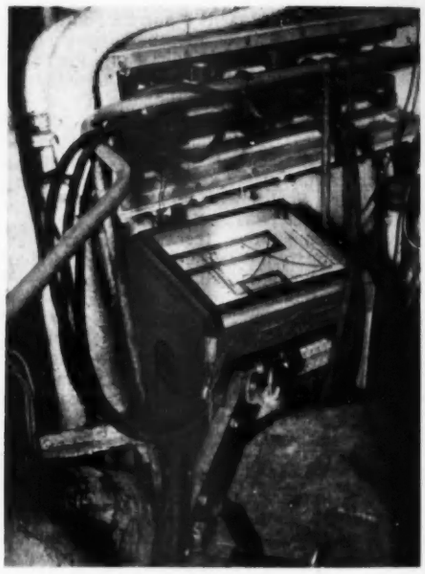
The E.A.F. equipment operates from a.c. mains at 220V, 50–60 c/s ; a converter is required for ships with d.c. mains. Output terminals cater for different cable sizes of 3/·036, 7/·029, 7/·036, 7/·044 and 7/·052. An additional cable terminal is labelled "O." Output voltage ranges are nominally labelled 2V, 5V, 10V, 15V, 20V, 25V, 30V and 60V a.c. respectively. A maximum output of 2kVA is available. The case measures about 15¾in by 21in and has a grey hammer finish.

To dry out a faulty cable the remote end is first short-circuited. Where there are more than two cores, it may be enough to use only two to carry the drying circuit. A multi-core cable can be completely short-circuited at the remote end and the cores separated into two groups at the other end and connected to the E.A.F. equipment as a two-conductor cable.

The correct drying current is chosen for a particular size of cable from a table inscribed on the equipment, and the voltage required to supply that current (which will vary according to the overall length of cable to be treated) is found by experiment on the output terminals. During the drying period, a test button can be depressed to switch off the drying current and switch in the megohmmeter to show the insulation resistance of the cable while it is warm, so that any latent insulation faults are more readily detected.

As the temperature of the cable rises, any moisture present moves towards the ends of the cable. Here the concentration rises rapidly, but because the supply voltage is low there is no flashover. As the temperature of the cable rises above the ambient level, the moisture is rapidly evaporated. Further penetration of moisture may then be avoided by finishing the ends of the cable with insulating varnish and tape.

When drying a larger cable the terminals marked with cable sizes can be ignored and the terminal marked "O" used. Thermostatic control does not operate in this case and the ammeter and voltmeter are used as checks.



Transportable apparatus for the *in situ* testing and drying of electrical gear affected by moisture. Here it is shown drying out an electrical installation on a cruiser

Damage to the cable through overheating will not result, and the E.A.F. equipment itself is protected against overloading by automatic fuses.

Testing and drying-out of motors can be done by testing through the supply circuit or by connecting directly into the terminal board of the motor. The heating of the motor in this case is largely achieved by utilising the iron losses.

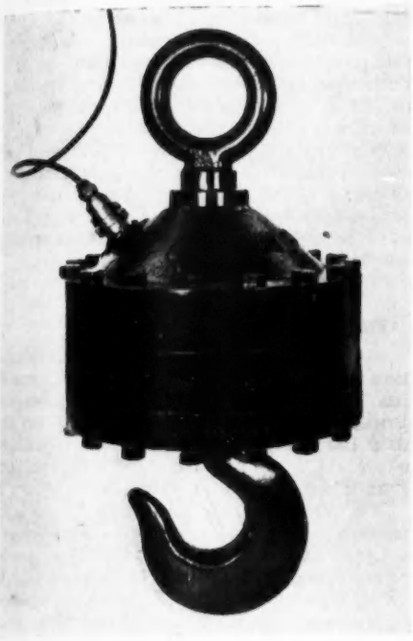
Perhaps the most useful function of the E.A.F. equipment is that of preventive maintenance. It also enables a ship's electrician to obtain a detailed knowledge of the installation and helps him to carry out repair or renovation of equipment while still at sea. It has been used in various marine applications, including the drying-out of a complete floating dock electrical installation that had been wholly submerged.

The E.A.F. equipment is made by Marinens Hovedvert, Horten, Norway ; A.E.I., Marine Department, Telecommunication Division, Woolwich, London, S.E.18, has sole marketing rights in all countries except Norway, Sweden, Denmark, Finland, France, Holland, Germany and the U.S.S.R.

[Reply Card No. E2202]

Electro-Hydraulic Tension Cell

AN electro-hydraulic tension cell with a built-in transducer has been introduced by Salford Electrical Instruments, Ltd., a subsidiary of The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2. It is specially suitable for crane weighing applications where it would give advance warning of overloading on the crane boom. To avoid difficulties of cable reeling the cell can be built into the crane structure. This robust cell constitutes a simple two-unit remote indicating system which has



Electro-hydraulic tension cell with built-in transducer

no power units or amplifiers, the only external requirement being a mains supply. Relays and other ancillaries are available to provide alarm or control facilities.

The equipment is illustrated here. The cell or hydraulic support is essentially a shallow cylinder having its piston or platen bonded to its walls by a flexible rubber joint. The space under the platen is filled with a suitable liquid which, for practical purposes, is incompressible if all air is extracted. As the volume of the liquid remains constant, there is no axial movement of the platen when loaded, so that none of the load is taken by the rubber joints and the whole is transmitted to the fluid. The platen, however, is virtually floating and can tilt to accommodate eccentric loading which is resisted by a balanced shear in the joint on opposite sides. This does not affect the hydrostatic measurement of the load.

A conical forged steel top dome houses an in-built Bourdon pressure transducer. Electrical connection to the transducer is via a demountable connector and a flexible three-way lead.

[Reply Card No. E2211]

Flow Control Valve

A VERSATILE valve for the control of fluid flow, which is adjustable to provide a good range of flow characteristics, has been designed in the United Kingdom Atomic Energy Authority's Capenhurst works, and is the subject of a patent application by the Authority. It has specially-shaped seating and closure sections which can readily be used with some existing commercial valve bodies. Both seating and closure sections carry tongues which are interleaved, but can slide between each other in such a way that the liquid is made to pass through ports defined by them.

Adjustment of flow characteristics is provided by a movable shutter over the spaces between the tongues on the closure section. This shutter normally rotates but can also be made to slide axially. In this case the choice is available of keeping the ports closed during the earlier part of the travel of the closure section, or of having a constant flow rate during the latter part of the travel.

Either form of shutter can be profiled to give a wide variation in flow rate characteristics. A rectangular profile would give substantially linear characteristics, while a logarithmic profile could be arranged to give a logarithmic pattern. A sealing ring mounted on the closure section co-operates with the seating section to provide for sealed closure of the valve. The axially moving closure section is carried by a valve spindle, the gland being made leak-tight through the use of a flexible metal bellows sealed at one end to the valve body and at the other to a disc integral with the valve spindle.

The valve can readily be adapted for automatic operation from a process controller and can be adjusted by conventional electrical or fluid operation without interfering with the automatic system controls.

[Reply Card No. E2212]

Traffic-Compatible Road Marker

To render a road perceptible in snow, or even in heavy rain and fog, a marker that rises above kerb level is desirable. A post of timber or concrete, however, is prone to damage and be damaged by the road users. A marker recently developed by Hamilton, Ltd., Cullingtree Road, Belfast, overcomes these objections; it is a post of rubber or neoprene, 18in to 2ft long, cored with a steel coil spring to resist abuse, topped with reflecting foil to improve its visibility, and having a reinforced base to set in concrete. It is claimed that the new marker is less expensive than a concrete post; a number have been installed on a stretch of new road in Northern Ireland.

[Reply Card No. E2213]

Thin Magnetic Films for Computing Devices

A LECTURE on "Magnetic Properties of Thin Films for Computing Devices" was given by E. M. Bradley at a meeting of The Institution of Electrical Engineers in London on February 7. The lecturer pointed out that the important difference in ferromagnetic behaviour between the bulk material and some thin films is that in a specially prepared film the electron spins contributing to the magnetisation can be made to rotate coherently rather than sequentially as in a domain-wall-motion process. The coherent-rotation process can be described with good accuracy by a simple model and can under certain circumstances be a very fast process. Both these properties are exploited in computer storage devices using thin magnetic films.

It has been found that the magnetisation-reversal process in small isolated areas of film of a size required for use in a computer store is not sufficiently coherent for a useful device to be made; this is thought to arise from the presence of edge domains. However, if the element area is selected from a large sheet by means of localised magnetic fields it has been found possible to obtain sufficiently coherent rotation. The localised magnetic field may be conveniently generated by passing a current through a strip line very close to the film.

Several modes of operation exploiting the fast coherent-rotation process are possible, all of which depend on control of the direction of the easy magnetic axis over the area of the film but do not depend upon accurate control of easy direction coercivity.

The method of measurement of the direction of the easy axis by a pulse technique was described in the lecture and comparison between films of nickel iron and a newly developed alloy, Gyralloy, was made. Finally, an example of a storage device was briefly described.

Proposed Underground Railway for Melbourne, Australia

FROM A CORRESPONDENT IN AUSTRALIA

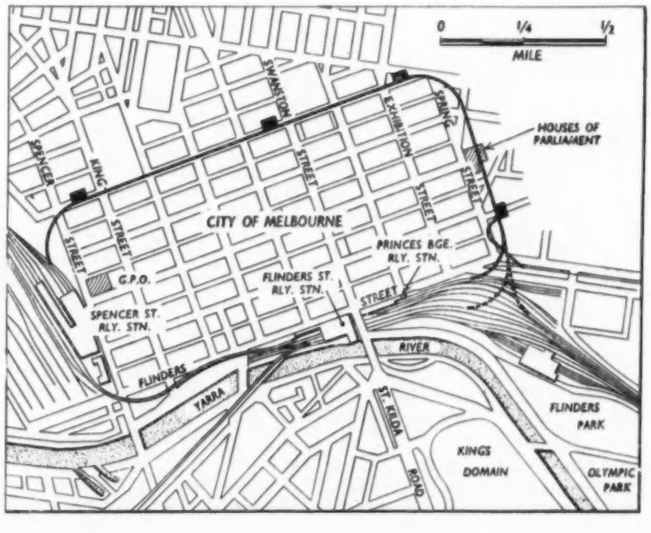
VICTORIA'S Minister for Transport, Sir Arthur Warner, has given notice of a Parliamentary Bill to authorise construction of a four-track underground railway loop around the main city business area of Melbourne, a rectangle approximately 1¼ miles by ¾ mile.

The present suburban railway system from some nine outer areas converges on one station, Flinders Street, on the southern rim of the main city area. Rural and interstate trains terminate at Spencer Street on the western boundary and the proposed loop utilises the existing tracks joining these two stations. Four new stations are provided for around the northern and eastern perimeter of the business area.

Most of the new sections of track and all four stations will be underground, but substantial surface construction will be necessary at the eastern junction of the new tracks with the existing marshalling complex at the approach to Flinders Street. An overpass to connect with a line to the north-east and tunnels to Flinders Street will necessitate three levels of track in what is at present park land.

Traffic density in normal hours is planned for twenty-four trains per hour, rising to ninety-six per hour in peak periods, with a route time of thirteen minutes to circle the city. All suburban trains, with the exception of those from two small feeder lines, will be routed round the new system in normal hours, but under peak conditions only six suburban routes will feed into the loop.

Project costs were estimated during 1959 at £25,000,000 (Australian), two-fifths of which it is proposed to meet by a special site rating to be levied on properties benefiting from the railway. Construction of the line will be in 5ft 3in gauge, and initially will be confined to areas where existing buildings are unaffected, such as public reserves and existing track areas.



Proposed route of underground railway, Melbourne

INDUSTRIAL NEWS

Stoppages of Work in 1960

The Ministry of Labour has announced that the number of stoppages of work in progress in the United Kingdom in 1960 due to industrial disputes was 2814, as compared with 2105 in 1959. These stoppages resulted in the loss of about 3,008,000 working days during the year at establishments where stoppages occurred, as compared with 5,270,000 working days lost during 1959. The aggregate number of workers involved in stoppages in progress in 1960 was about 811,000, the Ministry says, including nearly 116,000 workers who were indirectly involved. The corresponding total for 1959 was about 646,000 workers, including about 124,000 who were indirectly involved.

Nearly half of the rise of 704 stoppages of work beginning in 1960 as compared with 1959 was accounted for by a substantial increase in the number of stoppages in the coal-mining industry, from 1307 in 1959 to 1644 in 1960. The largest stoppage of work, the Ministry says, judged by the number of workers involved and the number of working days lost, was that involving 36,600 engineering apprentices which resulted in the loss of approximately 347,000 working days. The stoppage was in support of a national claim for increased wages. The largest stoppage in the engineering industry, apart from the engineering apprentices, took place in Lanarkshire when 730 workers employed in the manufacture of earth-moving equipment stopped work on November 2. The stoppage arose out of the dismissal of two shop stewards for trade union activities not recognised by the employer. A further 195 workers employed at a County Durham establishment of the same firm withdrew their labour on December 29. Work was resumed on January 9, 1961, nearly 32,000 working days having been lost in 1960. In the shipbuilding industry, the stoppage involving shipwrights and burners at Port Glasgow and Greenock eventually resulted in a total loss of 137,000 working days.

Dock Labour Scheme

Several amendments to the Dock Labour scheme, including some arising out of the recommendations of the Devlin Committee of Inquiry in 1956 and the reports of the inquiries carried out by Mr. Hugh Lloyd-Williams in 1959 and 1960, are proposed in a draft order published by the Ministry of Labour last week. They include amendments recommended by Mr. Lloyd-Williams applying the Scheme to the commercial port of Portsmouth and varying its application to cargoes of pitwood and timber. There is also an amendment, the Ministry says, which has been agreed with the National Joint Council for the Port Transport Industry, enabling any local dock labour board to delegate certain of its functions, including discipline, to a committee of the board or to an officer of the National Board. Amendments of a minor character which have also been agreed with the National Joint Council provide for the appointment of deputy members to local boards ; make it clear that a simple majority of those present and voting at a meeting of the National Board, a local board or committee constitutes a decision ; clarify the existing procedure relating to discipline ; vary the method of engagement of non-registered labour to fill vacancies for which the scheme already sanctions the employment of such labour ; and specify the industrial agreement to be observed when granting annual holidays with pay. Objections to the proposed amendments must reach the Ministry of Labour not later than March 24, 1961.

The Ministry points out that the amendments in this draft order are in addition to those made recently to facilitate the introduction of a pension scheme for dock workers.

Wages and Hours

The latest statistics published by the Ministry of Labour show that during 1960 there was an increase of 4 per cent in the average level of full-time weekly rates of wages in the principal industries and services, a reduction of nearly 2½ per cent in normal weekly hours of work and a consequential increase of just over 6½ per cent in hourly rates of wages. In manufacturing industries only, the Ministry says, the corresponding figures were 4½, 3, and 8 per cent respectively. Changes in rates of wages and hours of work coming into operation during 1960 resulted in about 11,000,000 workers receiving an aggregate increase of nearly £4,500,000 in their full-time weekly rates of wages and about 6,750,000 workers having their normal weekly hours reduced by an average of nearly two hours. The Ministry points out that as nearly 5,250,000 workers received both wage increases and reductions in hours, either simultaneously or at different times, nearly 12,750,000 of the total number of manual workers covered by collective agreements or statutory wages regulation orders—estimated at between 13,000,000 and 13,500,000—had wage increases and/or reductions in hours during the year.

According to the Ministry of Labour's statistics, in the industry group covering engineering and electrical goods, shipbuilding and marine engineering, vehicles and metal goods, some 2,339,000 workers received an estimated net increase of £1,032,400 in weekly rates of wages, whilst approximately 2,571,500 workers had an estimated reduction in weekly hours totalling 5,151,000 hours, during 1960.

Employment in Malta

Discussions between a delegation from the Confederation of Malta Trade Unions and Colonial Office Ministers on the employment prospects in Malta over the next few years have recently been held. The delegation was given a general forecast of employment prospects as seen by the Government of Malta and the Colonial Office, and these were discussed at meetings with the Minister of State for Colonial Affairs. The delegation urged that dismissals of redundant workers should be deferred until there had been a closer examination of the availability of alternative employment. It was explained that it would not be possible to halt present planning but that everything would be done to make the changeover in employment operate as speedily and smoothly as possible.

The Secretary of State for the Colonies welcomed the delegation's suggestion that a working party or similar body should be set up in Malta for the study of employment changes. He assured the delegation that the suggestion would be given early and very careful study. Having regard to the representations made by the delegation on the decline in apprentice and technical training in Malta, it was agreed that the problem of maintaining the supply of adequately trained apprentices and technicians should also be studied urgently. The delegation was advised that its proposal that recruitment for clerical and technical posts in the United Kingdom Civil Service should also take place in Malta would be taken up.

Further Education

A handbook entitled " Further Education for those in Industry and Commerce " has been published by the Federation of British Industries, in order to bring up to date the many different aspects of further education as they concern the employer or the student in his employment.

The booklet deals with recruitment and training, types of technical commercial colleges and courses, the growth of part-time release, the Industrial Training Council, group training schemes, the financial aspects of further education and the employer's contribution to further education. The handbook also contains a glossary of educational terms.

The need for such a handbook became clear, the Federation says, at its conference " Invest in the Future," held in Buxton in September, 1960, which discussed the problems of recruiting and developing managers, with particular regard to small and medium-sized firms. It was found, the Federation adds, that many firms had difficulty in keeping abreast with the changes in educational facilities that had been made since the war. Thus, for them, planned managerial development was made particularly difficult.

The handbook contains a summary of the recommendations of the Federation's conference. A full report is expected to be available in about a month.

Unemployment

The Ministry of Labour's final unemployment figures for Great Britain at January 16 show that 418,899 people were registered as unemployed, of whom 359,458 were wholly unemployed and 59,441 were temporarily stopped. The total included 48,793 married women and 8079 school-leavers. The number of people unemployed for more than eight weeks was 184,075, which was 51 per cent of the wholly unemployed.

The principal changes in unemployment between December 12, 1960, and January 16, 1961, the Ministry says, were increases of 10,200 in the motor vehicle manufacturing industry, including 10,100 temporarily stopped ; 2000 in furniture and upholstery manufacture ; 11,300 in other manufacturing industries ; 8600 in construction ; 7300 in distribution and 2500 in transport and communication. There was a decrease of nearly 1000, the Ministry adds, in shipbuilding and marine engineering.

PERSONAL AND BUSINESS

Appointments

MR. GLYN MITCHELL has been appointed a director of Pratt Precision Hydraulics, Ltd.

MR. T. V. EMMERSON has been appointed deputy chairman of Chamberlain Consolidated, Ltd.

MR. ALAN THRELFALL, A.M.I.Mech.E., has been appointed sales manager of Perkins Gas Turbines, Ltd.

INTERNATIONAL BOILERS AND RADIATORS announce that Mr. H. A. S. Moule has joined the board of directors.

MR. CHARLES F. DICKSON, a director of Crompton Parkinson, Ltd., has been appointed a vice-chairman of the company.

MR. W. R. NEW has been promoted to the position of branch manager of the Ayr office of the British Wagon Company, Ltd.

THORN ELECTRICAL INDUSTRIES, LTD., has announced the appointment of Mr. A. B. Tilleray as sales manager of its industrial control division.

MR. RICHARD ADAMS, M.I.Mech.E., M.I.Chem.E., has been appointed general manager of a newly created engineering division of Castrol, Ltd.

MR. S. C. TYRRELL, a director of Ransomes and Rapier, Ltd., has been appointed to the board of directors of Road Machines (Drayton), Ltd.

MR. F. K. DERRICK has been appointed managing director of Matbro Machine Tools, Ltd., a new subsidiary of the Matbro Group of Companies.

MR. SYDNEY PORTER has been appointed engineer commodore of the BP Tanker Company's fleet following upon the retirement of Mr. P. J. Hyde.

MR. JOHN MCWHINNIE ARMSTRONG has been appointed secretary of Dorman Long and Co., Ltd., in succession to Mr. R. S. H. Capes who has retired.

THE NORTH BRITISH RUBBER COMPANY, Ltd., announces the appointment of Mr. Colin McInnes as field sales engineer within the industrial products division.

THE CEMENTATION GROUP OF COMPANIES states that Mr. A. R. Neelands has accepted the position of president upon his retirement as chairman. Sir F. A. Pile, Bt., has been elected chairman.

IBM UNITED KINGDOM, Ltd., announces that Mr. Cyril Bottomley has been appointed the new manager of its time systems division. He succeeds Mr. E. Stafford Howard who retires after sixty-five years' service.

CHRISTY AND NORRIS, Ltd., announces that Mr. F. V. Mills has been appointed a director and will be responsible for sales, and Mr. L. Hammond has been appointed a director and will be responsible for finance.

THE ENGLISH ELECTRIC COMPANY, Ltd., announces that Mr. J. Y. McDonald has been appointed manager—diesel engines at its works at Preston. He has replaced Mr. J. H. A. Sharpley who has undertaken other duties.

M.O. VALVE COMPANY, Ltd., a subsidiary of The General Electric Company, Ltd., announces that Mr. N. Girton has been appointed as manager home sales and Mr. C. R. Russell has been made manager export sales.

MR. E. F. COPPOCK has been appointed group financial controller to Metal Industries, Ltd. He succeeds Mr. P. Jardine, who is taking up full time directorships with J. G. Statter and Co., Ltd., and Minerva Mouldings, Ltd., two M.I. subsidiaries.

ERSKINE, HEAP AND CO., Ltd., states that Mr. W. Briggs, director and manager of the contracts and sales department, has retired following a period of ill health. Mr. G. Webb, assistant manager for several years, has taken over as manager of the department.

THE MINISTRY OF POWER states that Mr. D. E. Fox, M.I.Min.E., A.M.I.Mech.E., A.M.I.E.E., has been appointed H.M. principal electrical inspector of mines and quarries in succession to Mr. J. Cowan, M.I.Min.E., M.I.E.E., who has retired from the public service.

MR. BRIAN H. TURPIN, managing director of Quickfit and Quartz, Ltd., and of Q.V.F., Ltd., has been appointed chairman of Q.V.F. Glass (Canada), Ltd., the Canadian subsidiary of Q.V.F., Ltd. Mr. J. G. Window, sales director of Q.V.F., Ltd., has been appointed a director of Q.V.F. Glass (Canada), Ltd.

THE METAL INDUSTRIES GROUP announces that Mr. J. M. Paul, M.I.E.E., has been appointed managing director of Foster Transformers, Ltd., and Lancashire Dynamo Nevelin, Ltd. Mr. Humphrey Bott, M.I.Mech.E., M.I.Mar.E., has been appointed chief engineer of Fawcett Preston and Co., Ltd.

THE BRITISH BROADCASTING CORPORATION has announced the following two appointments: Mr. J. B. Webb, A.M.I.E.E., as head of the valve section of the transmitter department in succession to Mr. H. S. Walker, A.M.I.E.E., who has retired after nearly thirty-eight years' service; and Dr. R. D. A. Maurice, A.M.I.E.E., as assistant head of the research department in succession to Mr. A. B. Howe, M.I.E.E., who recently retired after thirty-six years' service with the Corporation.

Business Announcements

THE MINISTER OF POWER, the Rt. Hon. Richard Wood, will open the British Petroleum Company's new Angle Bay Ocean Terminal, Milford Haven, on Thursday, April 20.

MR. HARRY RICHARDS, chairman of Wolf Electric Tools, Ltd., has retired after fifty-three years' service. He retains his seat on the board of Wolf Electric Tools (Holdings), Ltd.

MR. J. H. PATCHETT has retired from the board of directors of Dorman Long (Steel), Ltd., and from executive duties. He will continue to be available as a consultant to the company.

STERN AND BELL, Ltd., Stour Street, Birmingham, 18, states that its steel stockholding and forging divisions have been transferred to Warstock Road, Birmingham 14 (telephone, Maypole 3141).

THE CEMENTATION GROUP OF COMPANIES has opened a new research centre at Maple Cross, near Rickmansworth. The building is to act as the permanent headquarters for the Group's research.

MR. R. B. COULSON, sales manager of the English Electric Valve Co., Ltd., left London Airport on January 23 for an export sales tour which will include U.S.A., Canada, Australia, New Zealand, Japan and Ceylon.

MONSANTO CHEMICALS, Ltd., has announced a further expansion of polyethylene production facilities at the Fawley, Southampton, factory. The first stage will be fully operational early in 1963 and will add approximately 50 per cent to present capacity, which is in excess of 17,000 tons a year.

DECCA RADAR, Ltd., Albert Embankment, London, S.E.11, states that a group of senior engineers is being formed to inaugurate the company's research and development effort in the space electronics field. The group will shortly be transferred to new laboratory premises at Somerton Airport, Cowes, Isle of Wight.

THE MACHINE TOOL INDUSTRY RESEARCH ASSOCIATION was incorporated on December 22, 1960 (THE ENGINEER, September 23, 1960). The Association has announced that Mr. A. E. De Barr, B.Sc., F.Inst.P., at present a head of department at the Shirley Institute, has been appointed director of research and will take up his duties on April 1. The temporary address of the Association is c/o The Machine Tool Trades Association, Brettenham House, Lancaster Place, London, W.C.2. Forms of application for membership have been sent to those firms who gave the M.T.T.A. undertakings to support the research project.

Contracts

THE FURNESS SHIPBUILDING COMPANY, Ltd., has contracted to build for "Centromor," the Polish Government organisation, a floating dock of box design having a lifting capacity of 5500 tons. The dock will be designed by Clark and Standfield, Ltd., and have a length overall of 450ft and a width of 93ft 6in.

DAVY AND UNITED ENGINEERING COMPANY, LTD., a member of the Davy-Ashmore Group, has secured a contract worth over £500,000, to build a 32in and 57in by 98in four-high reversing hot breaking down and plate finishing mill for the works at Chippis, Switzerland, of Aluminium Industrie, A.G. The mill will be capable of producing aluminium plate up to 7ft 6in wide and down to ¼in minimum thickness.

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., Chelmsford, has reached an agreement with the Itek Corporation of Cambridge, Mass., U.S.A., whereby the Marconi company will manufacture and market the Itek Electro-Products Company's range of "Hermes" crystal filters. Marconi is permitted to market these devices in every country in the western world outside the United States. In addition, larger equipments made by Marconi's, which may include Itek "Hermes" crystal filters and discriminators, may be sold in the United States on a non-exclusive basis. The agreement will run for five years, with provision for extending it beyond the initial period.

HAWKER SIDDELEY INDUSTRIES, Ltd., is to supply M.I.F.E.R.M.A., an international consortium formed to exploit the iron ore deposits in the Khédra d'Idgil hills on the western edge of the Sahara, with four 3168 b.h.p. Mirrlees K.V.S.S. twelve-cylinder turbo-charged diesel engines driving Brush 2000kW alternators, together with a K.S.S. six-cylinder Mirrless/Brush set of 1000kW output, to power the electrically powered earth moving and mining equipment. To supply power for Port Etienne, seven Mirrlees/Brush diesel-driven alternators are to be provided, each consisting of a 1428 b.h.p J.V.S.S. twelve-cylinder turbo-charged engine driving a 1014kW alternator. All the alternators will be wound for 5500V, three-phase, 50 c/s supply.

THE HUNSLET ENGINE COMPANY, Ltd., and ROBERT HUDSON, Ltd., have received further orders for locomotives and rolling stock for the 2ft gauge lines of the Sudan Gezira Board, serving the board's cotton plantations. The locomotive order, totalling some £300,000, is for twenty-three 0—8—0 diesel-mechanical locomotives with 135 h.p. Gardner engines, developing a maximum tractive effort at site of 8620 lb. This is the sixth repeat order from the board for Hunslet locomotives specially designed for service on its system. Rolling stock to be supplied comprises 580 open goods wagons, 123 closed wagons and a number of tank wagons, guards vans and rubber-tyred low-loader trailers also at a value of some £300,000. The equipment is for service on the Sudan Manogil extension scheme.

Miscellanea

JET FLAP RESEARCH AIRCRAFT.—The jet flap research aircraft under construction by Hunting Aircraft, Ltd., has the designation ER-189D and Bristol Siddeley "Orpheus" power plant.

AFTER-BURNING TURBOJET.—The de Havilland "Gyron Junior" DGJ-10 flew for the first time last month in a Gloster "Javelin." The engine is claimed to give 10,000 lb thrust sea level static and over 20,000 lb thrust at 36,000ft and M. 2·5 with reheat to 2000 deg. K.

MOTOR VEHICLE PRODUCTION.—The production of motor vehicles in Great Britain increased again in 1960, continuing its trend over the last four years since 1956. Production of cars was 1,352,728, of goods vehicles 438,924 (this figure has been increasing only since 1957), and of public service vehicles, 19,048.

Deaths

THE death occurred on Saturday, January 28, at the age of seventy-five of Mr. A. W. C. McArthur, a former member of the board of W. T. Henley's Telegraph Works Company, Ltd. Mr. McArthur, who started work at the age of fourteen, became works manager of Henley's Woolwich Works in 1939, a position he occupied for thirteen years. In addition he was works manager of the company's Birtley Works during its formative years from the time of its opening in 1950. In 1950, also, he completed fifty years service with the company and was elected to the board. He retired in 1958.

We have also learned with regret of the death on January 30 of Mr. William McKay, M.I.Mech.E., M.Inst.F., managing director of La Mont Steam Generator, Ltd. Mr. McKay, who was fifty-eight years of age, had held the office of managing director for the past year, having previously served as chief engineer since 1947. Prior to joining the company he was head of the La Mont boiler department of Ivor Power Specialty Company, Ltd., and was for some years a member of the technical staff of International Combustion, Ltd.

CONTINENTAL AFFAIRS

by Our Continental Editor

Development of Port of Rotterdam

With the astonishingly rapid recovery and subsequent further expansion of the European economy, traffic in the Port of Rotterdam, the "Gateway of Europe," has reached a level which not so long ago would have been considered Utopian. Farsighted planning on the part of the authorities is making it possible to grasp the opportunities which are offering themselves. In particular, the growing importation of basic raw materials from overseas countries requires additional means of bulk handling and storage; and the tendency towards increasingly large oil tankers necessitates the construction of docking and discharge facilities for such vessels and more storage capacity on shore. The seaward expansion of the port, which after the war led to the building of the Botlek Harbour, is continuing with the construction of "Europort," a vast scheme which eventually can even be extended a considerable distance beyond the present shoreline. Completion of the first stage is imminent.

ROTTERDAM, situated within the metropolitan area of the western Netherlands, has a population of over 730,000 inhabitants, and within a 30-mile radius there live 3,000,000 out of the country's 11,000,000 people. The city suffered extremely heavy damage in the German air raid of May 14, 1940, when practically the entire centre, extending over 642 acres, was wiped out, as well as a large part, 247 acres, of the east district. When the occupation forces retreated in the autumn of 1944, they blew up more than 8500 yards of quays (over one-third of the total length of quayside for sea-going vessels) and destroyed some 40 per cent of the port equipment. This physical destruction, together with the deportation of tens of thousands of men, meant almost complete economic paralysis at the end of the war, and prospects were further darkened by the collapse of the German hinterland and the damage sustained by France's eastern provinces. Nobody at the time could foresee the phenomenal recovery of Germany, upon which so much of Rotterdam's prosperity depends.

Immediately after the bombing the debris was cleared away and the ruins and foundations of bombed buildings were removed. Replanning of the reconstruction was begun at once, and in order to make this possible on the scale required, 12,000 buildings and their sites with a total area of 415 acres were expropriated, including 1500 undamaged buildings on the fringes of the devastated area. Outside the city, 1552 acres were expropriated with a view to laying out new housing and trading estates, and some neighbouring municipalities were incorporated in 1941. Although some important construction work was carried out, all operations were completely stopped in July, 1942. Nevertheless, planning proceeded behind the scenes, with the result that already in May, 1946, the so-called "Basic Scheme for the Reconstruction of the City of Rotterdam" was ready to receive the approval of the provisional City Council and, shortly afterwards, of the Government.

If Rotterdam was to survive at the end of the war, top priority had to be given to the reconstruction of the port upon which the city depends. An executive authority, "Diwero," which had already undertaken clearance of debris and other public works in the inner city, was given the task of supervising the rebuilding of the port. This was begun in June, 1945, by a group of five Dutch and three British contractors, and completed in December, 1949. Since then, the port facilities have been augmented and extended, a process which is still continuing steadily. To-day, Rotterdam can berth and handle over 287 sea-going vessels alongside its quays, jetties, buoys and dolphins. There are over 25,000 yards of quayside for sea-going vessels, over 14,500 yards of quays for inland craft, about 350 cranes, 260 of which have a capacity of 5 tonnes, and twenty-five loading bridges, together with eighty-eight floating cranes for bulk and general cargoes and sixteen floating grain elevators. In addition there are thirty-six heavy floating cranes, the largest five having a lifting capacity of 200 to 250 tonnes (Figs. 1, 2 and 4).

The port possesses twenty-four floating dry docks which have a total lift capacity of 372,000 tonnes, the largest being able to dock vessels of 54,000 tonnes. Sheds and warehouses have a combined floor area of over 5·92 million square feet, and there is open storage area over 10·76 million square feet. In addition, there are cold storage warehouses with a floor space of 201,000 square feet and a total volume of 1·96 million cubic feet, fruit stores with 297,000 square feet of floor area and a volume of 3·53 million cubic feet, granaries capable of storing 215,000 tons, and tanks for 435,000 tons of edible oils.

Storage capacity for mineral oils last year amounted to about 6,000,000 tons. The port has 170 tugs of 75 to 600 i.h.p. and nineteen sea-going tugs of up to 4200 i.h.p.

Table I gives an impression of the post-war development of the port's traffic, with figures for 1938 (the pre-war peak year) added for the purpose of comparison. In addition to sea-going vessels, about 200,000 barges of up to 4000 tons enter the port annually, and transhipment of bulk goods to and from these barges forms a large proportion of the total business. Altogether, the port gives employment to 13,000 to 14,000 dockers. Last year, about 6,250,000 shifts were worked. This compares with 6,750,000 shifts in the post-war peak year, 1957.

TABLE I.—*Traffic in the Port of Rotterdam*

Year	Number of incoming sea-going vessels (thousands)	Total tonnage (millions net register tons)	Sea-borne goods traffic (excluding bunkers) (millions metric tons)
1938	15·36	24·7	42·4
1946	4·46	5·9	8·1
1948	8·50	12·7	15·8
1950	12·88	20·4	29·7
1952	15·44	25·4	39·8
1954	18·02	32·8	48·8
1956	21·24	43·3	72·2
1957	22·03	45·0	74·1
1958	21·96	48·5	73·8
1959	—	49·9	70·7

Next in importance to the general growth of traffic which has occurred since the war has been the relative increase in bulk goods, and the relative decrease of transit traffic as compared to national traffic.

With regard to the class of goods handled, i.e. whether bulk or general cargoes, it is instructive to compare the position in the ten years 1929–39 with the period 1949–59. Before the war, the amount of general merchandise fluctuated only slightly around the 7·5 million-tonne mark,

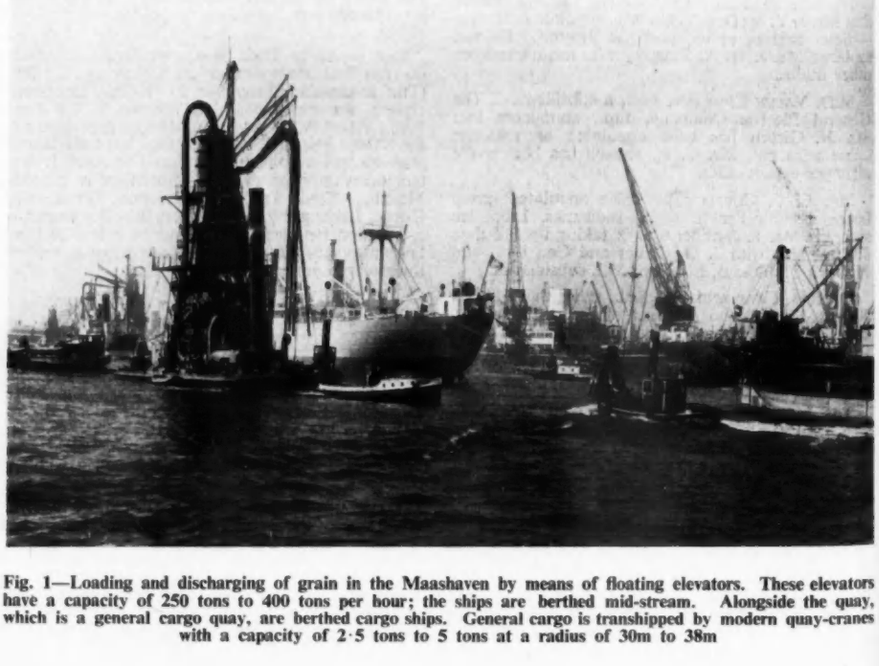


Fig. 1—Loading and discharging of grain in the Maashaven by means of floating elevators. These elevators have a capacity of 250 tons to 400 tons per hour; the ships are berthed mid-stream. Alongside the quay, which is a general cargo quay, are berthed cargo ships. General cargo is transhipped by modern quay-cranes with a capacity of 2·5 tons to 5 tons at a radius of 30m to 38m

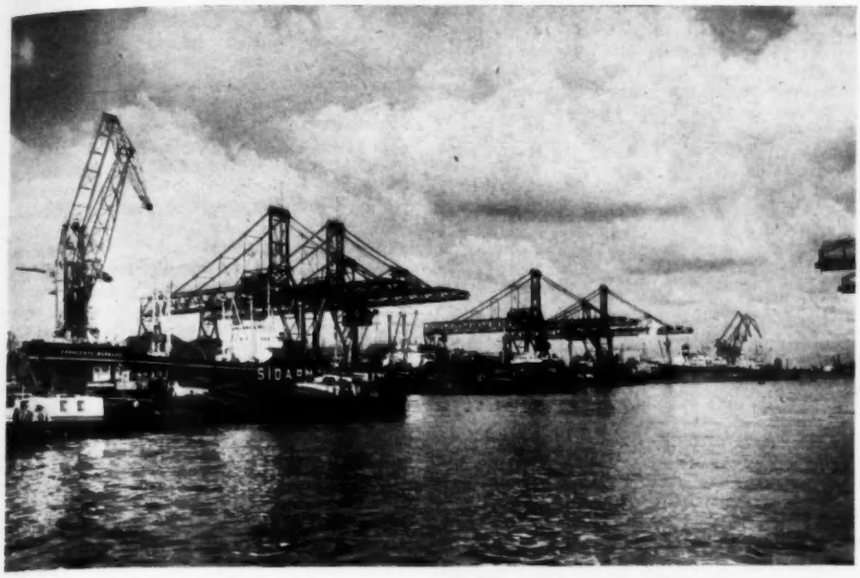


Fig. 2—Transhipment of dry bulk cargoes in the Waalhaven with loading bridges and level-luffing grab cranes. The loading bridges have a lifting capacity of 16 tonnes, the cranes 10 tons to 12 tons, with 40m radius

while bulk goods were much more drastically affected by the years of economic crisis, dropping from 30,000,000 tonnes in 1929 to 15,000,000 tonnes in 1932, thereafter rising to a peak of about 35,000,000 tonnes per annum in 1937–38, only to fall away again sharply in the year the war broke out.

After the war, general merchandise advanced with only minor fluctuations, from 5,000,000 tonnes in 1949 to 13,000,000 tonnes ten years later. During the same number of years, bulk traffic, mostly due to oil transports, shot up by leaps and bounds from 15,000,000 tonnes to 56,000,000 tonnes, with a 62,000,000-tonne peak in 1957. (These figures are exclusive of bunker materials.) If one looks at the bulk traffic figures, one notices the high position occupied by mineral oils : in 1959, for instance, oil shipments in both directions totalled 31·54 million tonnes (without bunkering materials), while dry bulk goods amounted to 24·7 million tonnes. Table II gives a brief synopsis of these movements. As compared with 1938, shipments —excluding mineral oils—increased in the case of fertilisers, general merchandise and cereals, and declined in other branches leaving the total almost unchanged. Oil shipments in both directions, on the other hand, showed an increase to nearly eleven times the 1938 figure.

Transit traffic before the war accounted for 58 to 75 per cent of the total. It also was responsible for the greater part of the fluctuations which the port traffic underwent in the 1930's. Transit traffic, reflecting the trends mostly of the German economy, by 1932 had decreased by 62 per cent below its 1929 volume, only to increase 17 per cent above this figure by 1937–38. The corresponding variations of national traffic were much less marked ; the fall below the level of 1929 amounted to only 25 per cent and was much less abrupt ; by 1937, traffic had regained more or less its 1929 position.

TABLE II.—*Sea-going Goods Traffic in the Port of Rotterdam*

(Millions of tonnes, exclusive of bunkers)

Year		Coal	Ores	Fertilisers	Cereals	Others	Total dry bulk goods	Mineral oils	General merchandise
1938	inwards	0·8	11·0	0·51	3·64	1·63	17·58	2·69	4·23
	outwards	10·2	0·05	0·82	0·24	0·64	11·95	0·23	3·57
Total		11·0	11·05	1·33	3·88	2·27	29·53	2·92	7·80
1957*	inwards	11·85	8·96	0·86	3·68	1·86	27·21	21·25	6·74
	outwards	3·85	0·03	1·62	0·07	0·37	5·94	7·16	4·16
Total		15·70	8·99	2·48	3·75	2·23	33·15	28·41	10·90
1959*	inwards	2·91	8·46	1·32	5·70	1·46	19·85	23·16	8·18
	outwards	2·17	0·00	1·85	0·31	0·50	4·83	8·38	4·80
Total		5·08	8·46	3·17	6·01	1·96	24·68	31·54	12·98

*Under the new classification of January 1, 1957, certain kinds of general merchandise were re-classified as bulk goods.

Since the end of the war, the Dutch have endeavoured to provide employment by creating more industries, mostly in the western part of the country. The success of this policy is reflected in the higher proportion of national traffic now handled by the ports, and in particular by Rotterdam, where it has increased between 1949 and 1959 from about 12,000,000 to 45,000,000 tonnes or by 275 per cent, while transit traffic went up from 15,000,000 to 48,000,000 tonnes, an increase of 210 per cent. As during the crisis of the 1930's, the recessive trend noticeable in transit traffic since 1957 was followed shortly afterwards by a drop of lesser extent in the national traffic. These developments bear out the decreased dependence of the port on its foreign hinterland, and the greater economic stability which is the result.

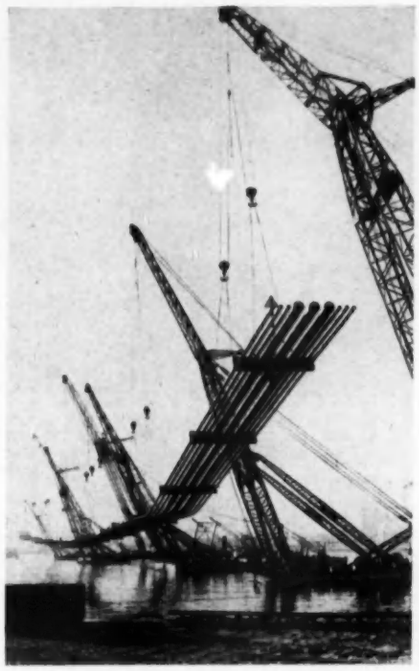


Fig. 4—A 370m long multiple oil conduit (six pipes of 600mm diameter and three pipes of 1200mm diameter) being picked up by floating cranes. Placed across the Oude Maas, it connects the Botlek and Europort areas with Pernis and the pipeline to the Rhineland

Rotterdam is a municipal port, i.e. the water and the quays belonging to the harbour are owned by the municipality of which the port administration forms a department. An exception is the channel of the Nieuwe Maas and part of the Koningshaven which belong to the State, and some land sites belonging to shipyards and industrial concerns and to the Netherlands railways. The municipality, through its port administration, leases sites and even warehouses and equipment to commercial firms ; thus of the present total of 350

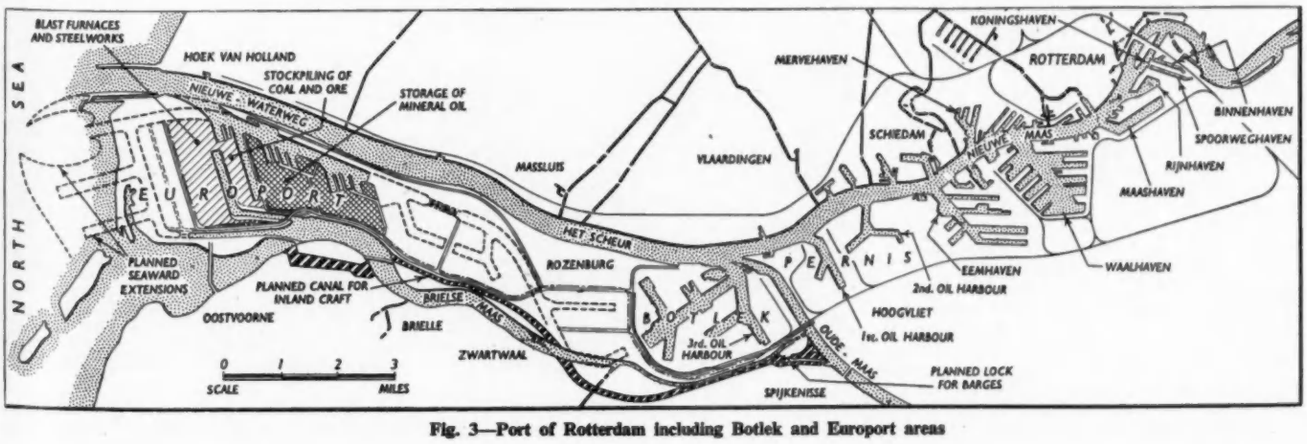


Fig. 3—Port of Rotterdam including Botlek and Europort areas

CONTINENTAL AFFAIRS *(Continued)*

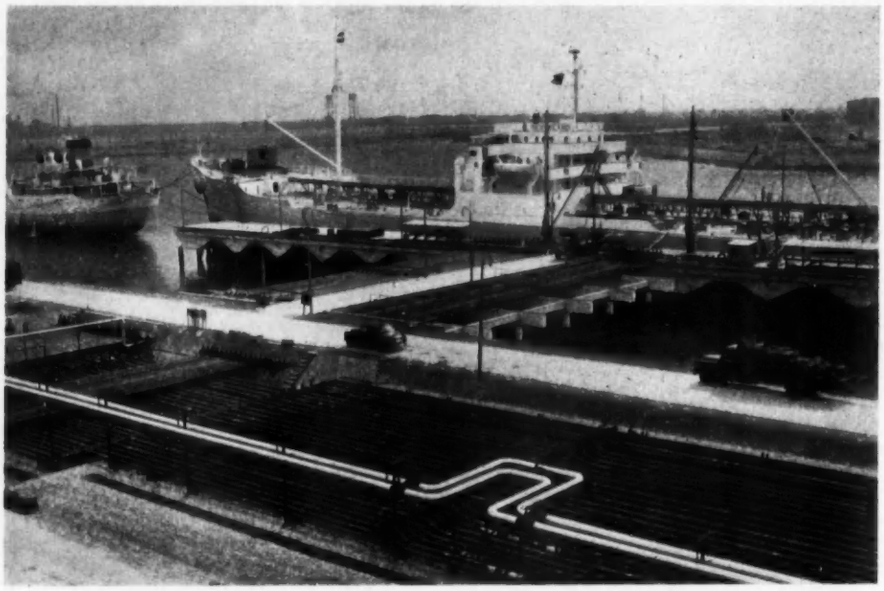


Fig. 5—Oil jetty (N. Matex) in the Third Oil Harbour (Botlek area), for tankers of up to 50,000 tons deadweight. The berth is connected by pipelines with the tank farm behind. On the horizon, the towers of lifting bridges over the Oude Maas, and part of Pernis refinery on the left

dockside cranes, 140 belong to the municipality.

Our illustration (Fig. 3) shows the Port of Rotterdam with its favourable position at the mouth of the Lek, as the northern arm of the Rhine delta is called. This part of the river changes its name several times, becoming in turn the Nieuwe Maas, Het Scheur, and the Nieuwe Waterweg, the latter name deriving from the cutting made in the last century at the Hook of Holland, which gave a direct opening to the sea at a point where previously there had been a sharp loop to the south.

The modern development of the port began in the 1870s near the centre of the town with the construction on the left bank of the Binnenhaven and Spoorweghaven, at that time used for the import of ore and export of coal. These were followed in 1894–1905 by the basins of the Rijnhaven (69 acres) and Maashaven (148 acres), and the large Waalhaven (1907–31, 741 acres).

While the basins on the left bank were built mostly for the discharge and transhipment to barges of bulk goods, the harbour basins on the opposite bank of the river, which were developed from about 1890 to 1932, are for general cargo. Nowadays the tendency is to concentrate bulk cargo traffic in the western parts of the Waalhaven and convert the rest to the handling of more profitable general cargo. The whole of the port area is served by a network of road and rail connections. The total lengths of railway track amounts to 300km, and the daily turnover capacity is 1600 wagons. About 80 per cent of the transit traffic is by water and the remainder goes overland.

The next large group of basins downstream of the Waalhaven is the Eemhaven (37 acres) which is still being extended. Two further basins are to be put into service by 1963–64, and the depth, which is now 11ft to 17ft, is to be increased to 33ft. The Eemhaven is to be developed for general cargo.

Until 1936, an oil storage area of 69 acres existed in the north-eastern part of the Waalhaven. There was also a small petrol refinery belonging to the " Shell " company. Because of the potential danger of oil cargoes and lack of space at the original site it was decided to construct separate facilities further downstream. Thus came into being the First Oil Harbour (1929–33), the Shell refinery Pernis (1936), and the Second Oil Harbour (1938–55). All these cover a total land area of 1300 acres.

Botlek Harbour

The increasing demand for oil products after the war, as well as the need for coal and ore storage areas, led to plans being approved in 1947 for the Botlek area, involving 3240 acres (1310 hectares). This area is on the island of Rozenburg, at the end nearest to Pernis, from which it is separated by the Oude Maas, an important shipping lane. As it was necessary to create an access from the land side, the building of a bridge over the Oude Maas was therefore the first stage in the operations. This bridge was begun in December, 1952, and completed in the spring of 1955. The Third Oil Harbour which has been constructed in the Botlek area is the largest of the three, with a water area of 198 acres, and like the other two, has a water depth of 36ft (Fig. 5). Installations included an Esso refinery and other oil and petrochemical plants, a shipyard (Verolme) capable of building vessels of up to 100,000 tons, and an ore and coal storage area (Müller-Hanna). Whereas the First and Second Oil Harbours can be entered by vessels of 45,000 tons deadweight, the Botlek and Third Oil Harbour can take vessels up to 60,000 tons deadweight.

Botlek Ore Storage

Importation of overseas iron ore, in particular from Labrador and South American mines, necessitated the provision of new storage capacity, alongside one of the basins of the Botlek Harbour. The present site was jointly selected in 1956 by Wm. H. Müller and Co. N.V., Rotterdam, and the Hanna Mining Company, Cleveland, Ohio, as being adequately large for present requirements, with more space available for expansion (Fig. 6). A large central storage area is particularly essential with Labrador ore as the season is limited to an average of seven months per year, during which time the yearly contract quantities must be shipped, and most steelworks lack the space for stockpiling of their own.

The ore arrives from the port of Seven Islands in 45,000-ton carriers which with adequate loading and unloading facilities achieve a turnround time of twenty days, or ten trips a season. If handling facilities are inadequate or storage space is insufficient, so that direct transhipment to barges becomes necessary, the number of trips per season may easily be reduced by a fifth, thereby sizeably lowering the ships' carrying capacity and increasing the cost of transport. Direct unloading into barges frequently entails much waiting time, as barges are not always available.

Stage I of the storage facility, which came into service last year, has a dock frontage of 700m made up of a 500m long unloading section and a 200m long loading section.

The unloading section is equipped with two (later four) rail-mounted self-propelled unloaders with 12-gross-ton clamshell buckets, each with an hourly capacity of about 650 gross tons of iron ore of 135 lb per cubic foot when discharging from a modern ore carrier of 15,000 tons or

Fig. 6—Muller-Hanna ore and coal storage area (Botlek Harbour). The site is served by a belt conveyor system with a capacity of 1500 tonnes to 2000 tonnes per hour

greater. The free-digging capacity per machine is over 1000 tons per hour. The unloading frontage is sufficient to berth two large ore ships simultaneously and has been dredged to a depth of 40ft below N.A.P.

One barge and ship loader has been installed in the first stage. It has a loading rate equal to the free-digging rate of the two unloading towers, and is capable of loading two barges moored alongside each other.

There are three stockpiles which run in a direction parallel to the quayside. Movement of ore into and out of storage is effected by conveyors working in conjunction with a stacker and a reclaimer. These two machines, and one of the longitudinal conveyors, are stationed between the second and third pile, and serve those piles. The dockside pile is charged and discharged by the 12-ton unloaders operating in conjunction with the dockside longitudinal conveyor which also carries the ore to the barge and ship loader. The ends of the two long conveyors are connected by shorter transverse conveyors running at right angles to the quay outside the area covered by the stockpile. All the machines, unloaders, loader, stacker and reclaimer are electrically-operated, rail-mounted, and self-propelled.

The stacker has a discharge conveyor mounted on a boom which can be derricked up to 18 deg.

Fig. 7—Cutting through the dyke dividing Europort basin (right) from the Nieuwe Waterweg (August 31, 1960)

for ore and 21 deg. for coal, and slewed through 210 deg. It is rated at 4000 gross tons of iron ore per hour, as this is the capacity which will be required when two further unloaders are installed in a subsequent stage of development.

The reclaimer is equipped with a 12-gross-ton bucket and has a capacity of about 1100 gross per hour. A building to house offices, a maintenance workshop, and the electrical substation, have also to be erected.

The unloading and loading quays take the form of concrete rafts resting on steel and concrete piles, the latter of 16½in square section precast at the site. The concrete foundation piling for the stacker-reclaimer rails was cast *in situ* by the "Vibro-pile" system. The layout permits the later installation of railway tracks if this should become desirable. A further three stages of expansion are envisaged. The additional unloaders, a second ship-loader, a second quayside conveyor, and two additional end conveyors will be installed in the next stage, which is to be followed when necessary by a second and third stacker-reclaimer system.

"Europort" Scheme

Taking a long-term view of the evolution of the Port of Rotterdam, the city council realised that development would have to go beyond the Botlek area, and decided to construct at the head of the island of Rozenburg opposite the Hook of Holland a series of barriers for very big vessels. This is the so-called "Europort." Our first illustration indicates the layout of the area. After completion of part of the first basin, an entrance is being opened out into the Nieuwe Waterweg (Fig. 7), the breakthrough on August 31 being the occasion for an official celebration. It is hoped to bring the basin into use early in the year.

Mooring facilities for large oil tankers and oil derricks have been installed, and storage tanks on shore are already providing overflow capacity for Pernis. The oil harbour is connected through Pernis to the Rotterdam–Rhine pipeline, a 24in pipe which branches at Venlo south towards Godorf and Wesseling, and north towards Wesel from where a previously existing 16in diameter pipe forms a connection with Gelsenkirchen (Fig. 3). The pipeline came into operation on June 27, and on July 15 the Shell refinery at Godorf was officially opened.

The Europort scheme covers an area of 3828 acres (1550 hectares) of which 2290 acres will be industrial sites, some 990 acres will be excavated to form harbours and canals, and about 550 acres will be required for engineering purposes, or for various reasons will not be leased at all. These figures may be compared with the 2050 acres (850 hectares) of rentable land which the completed Botlek plan will provide.

The scheme represents a long-term plan for expanding the facilities already in existence for the importation in bulk of such basic materials as oil, iron ore and coal. At the time the plan was finalised, the annual growth of oil consumption in Europe in the 1960s was estimated as 7·5 per cent, with other materials increasing on a similar scale. While it must be expected that these trends may be reversed temporarily, it is considered that over a long period a further substantial expansion will take place, as raw materials and energy consumption in Europe is still small compared with that of the U.S.A.

At the same time, the growing European needs can only be met with the help of imports from more remote parts of the world which in order to be economic require the use of very large ships. Examples are the oil tankers of 70,000 and 100,000 tons which have already come into service, and large ore carriers. While the Botlek Harbour can take tankers of up to approximately 47,000 tons, the first Europort basin will be accessible to tankers of 65,000 tons deadweight with a draught of 38ft. Subsequently the minimum depth of water will be increased from 43ft to 49ft, so that it will be possible to accommodate vessels of up to 100,000 tons deadweight.

The decision to push on with the Europort project even before completing the Botlek Harbour stems from two reasons. When in 1958 it was decided to build the Rotterdam–Rhine pipeline, this had been made conditional upon the provision of facilities for discharging supertankers and of additional oil storage. Secondly, there was the necessity to complete the first stage before 1961, when the Delta Plan would begin to tie down a large proportion of the country's dredgers.

At the beginning of 1958, the Rotterdam City Council voted 73,000,000 guilders for the purchase of land and for the initial works which comprised the construction of dykes, the removal of 300 wartime concrete bunkers, dredging and embanking operations. Tendering took place in May of the same year and operations began the following month with the building of dykes. In September work was begun on the sea harbour proper, and on the inland shipping harbour which for the time being will be connected to the Brielse Maas, an arm of the river cut off from the sea since the dyke was closed on July 3, 1950.

Dredging of the sea harbour was started not from the new waterway but from the canal through Rozenburg, since it was necessary to complete the main dyke round the harbour before cutting through the dyke running along the Nieuwe Waterweg. In this manner most of the dredging could be carried on in non-tidal water. The scale of the operation can be gauged from the fact that the main part of the first barrier is 300m wide and that its northern side will initially be 4·6km long. The coal and ore basin will be about 1·9km along and 230m wide, while the inland shipping basin which will run parallel to it along the other side of a 470m wide storage area, will be of about the same length and will have a width of 260m. In the first stage a basin area of 630 acres (225 hectares) will be constructed. The material removed by the dredgers is conveyed hydraulically through pipes and used to spoil up the surrounding land areas to a height of 16ft 9in (5·5m) above N.A.P., the level prescribed since the flood disaster of 1953.

Along the southern side of the sea harbour will be sited the oil jetties, and the extensive area between the basin and the Brielse Maas will be used for large-scale oil storage.

To the west of the inland basin a large site has been reserved for blast furnaces and a steel works. This, however, is a somewhat controversial project which is being strenuously opposed, in particular by the Ijmuiden Steel Works, and no final decision has been taken with regard to the steel works.

For the use of inland shipping a canal will be dug through part of the Brielse Maas to the Oude Maas using the Hartel Canal which will be deepened and widened. A new lock, 78ft wide, will be constructed between the Oude Maas and the canal so as to allow the passage of 60ft to 65ft wide pusher barge trains.

The cost to the Rotterdam Municipality of plans now being executed is estimated at about 150 million guilders. This figure includes the cost of the land, but excludes quay walls and the capital expenditure of the Municipal Electricity Board and of the Municipal Drinking Water Supply.

Before actual work could begin, the area had to be cleared of the remnants of Atlantic Wall defences, from which were obtained 154,000 cubic yards of concrete rubble which was used for revetments of the harbour slopes.

Construction of the harbour and retaining dykes required about 2·75 million cubic yards of soil, while between the retaining dykes about 37,000,000 cubic yards of soil was spoilt up hydraulically to a final level of 5·5m (18ft) above N.A.P. Dredging has been in progress since September 13, 1958, by means of modern cutter dredgers with a capacity of about 110,000 cubic yards per week; the dredgers can pump the spoil over distances of up to 2 miles.

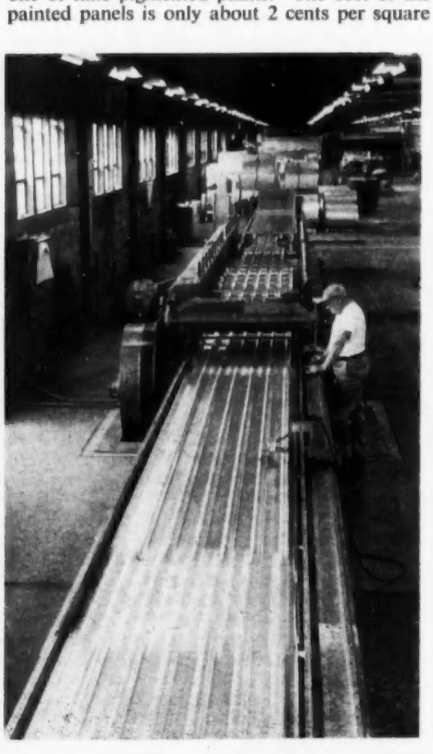
THE AMERICAN SCENE

By Our American Editor

Colour Finishing of Galvanised Steel Sheet Panels

In the field of prefabricated metal buildings the era of the Quonset or Nissen huts has come to an end. The modern prefabricated steel building has aesthetic appeal due largely to the use of attractive design and colour. The Stran-Steel division of the National Steel Corporation originated the Quonset hut during World War II and has now developed a new line of modern prefabricated single-storey buildings employing galvanised steel sheet sidings and panels. This article describes fabricating and finishing operations at the firm's works in Terre Haute, Indiana, where the building components are produced.

AFTER producing its last Quonset hut of corrugated sheet design in 1959, the Stran-Steel division of the National Steel Corporation, of Pittsburgh, completely re-arranged its production facilities at Terre Haute, Indiana, to suit modern and attractive designs of prefabricated single-storey buildings. Although the success of the new building concept has hinged on attractive design, much of it stems from the sheet which covers the buildings. The company has changed from the once-standard corrugated design to ribbed galvanised siding and has employed a prefinishing process which applies a long-lasting paint to the sheet before it leaves the plant. To make the new siding, coils of galvanised steel sheet are sent through two lines. One forms the strip to the desired shape, cuts it to size and sprays on a primer or bond coat. The second line covers the primed panels with one of nine pigmented paints. The cost of the painted panels is only about 2 cents per square foot more than those which are unpainted. Its use, therefore, represents a considerable saving since painting in the field, after the building is up, costs from 10 to 12 cents per square foot.



Flow of galvanised sheet steel from 10-ton coils through 15-stand roll forming mill to flying shear

Roll Forming

The 600ft long operation starts out at a point where a 10-ton coil of galvanised continuous strip steel is loaded on an uncoiler at the front of the roll forming equipment. From the uncoiler, the 41½in wide strip is flowed out on to a motorised belt conveyor for threading into the roll forming mill. On the mill are fifteen forming stands, each of which progressively shapes the continuously moving strip into the rib-type panel design for steel building roofing and siding coverage. After roll forming, the panels are 38in wide to provide a net 3ft wide coverage with 2in lapping in field installation.

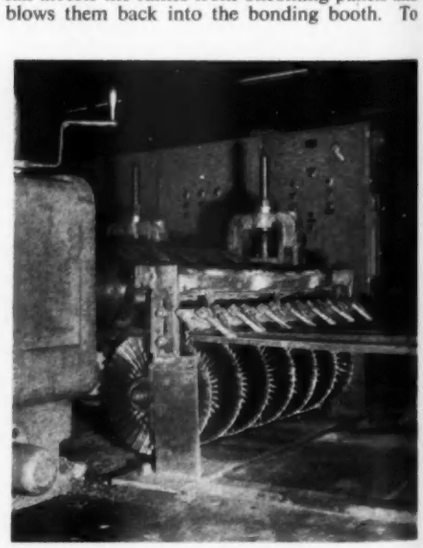
Leaving the fifteenth stand of the roll forming mill, the panel passes through a wire brush cleaning unit prior to entering the bond coating booth. This cleaning unit comprises a series of straight stiff wire brushes mounted above the strip and impinging upon the flanges of the formed ribs. A series of power-driven steel brushes do the same job on the underside of the strip, which is moving along at 95ft per minute. The strip then moves between the jaws of a slug-type flying shear. Controlled by an adjustable cut-to-length gauge located on the run-out table, the shear removes ½in of steel to leave the panel with both a clean leading and trailing edge. The sheets are cut to standard lengths ranging from 4ft to 35ft.

Bond Coating

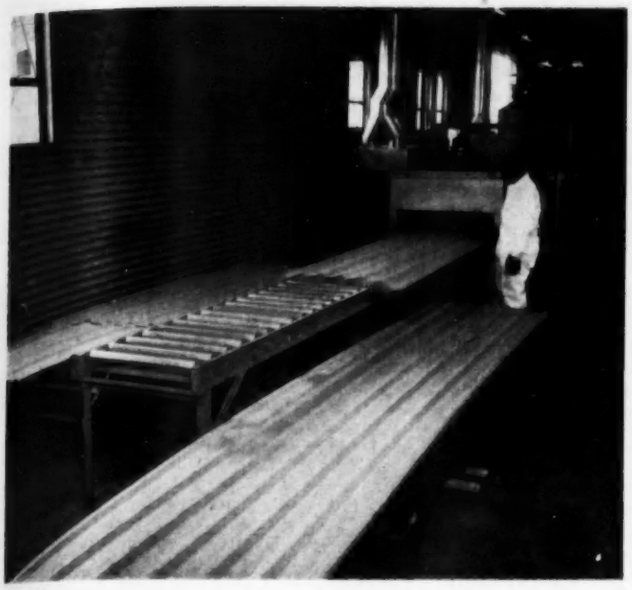
An extension of the run-out conveyor from the roll forming equipment automatically transfers the cut-to-length panels on to a pin-type conveyor leading into the bond coat booth. This conveyor moves the panels at the accelerated speed of 105ft per minute, so that they will be spaced out for entry into the bond coat booth. In this conveyorised spray booth, five spray guns operating in a straight line arrangement completely cover the width of the panel with a reactive primer material. This bonding agent simultaneously "phosphatises" the galvanised coating and deposits a corrosion-inhibitive film. The five-gun stationary spray operation is controlled by a memory-timer that automatically memorises and remembers the length of the panels as they pass over a micro-trip signal. Thus, the five-gun arrangement is signalled to spray just as the panel is ready to move under it and to stop spraying when the panel moves out of target range.

Close-up view of 15-stand roll forming mill for the production of ribbed roofing and siding panels

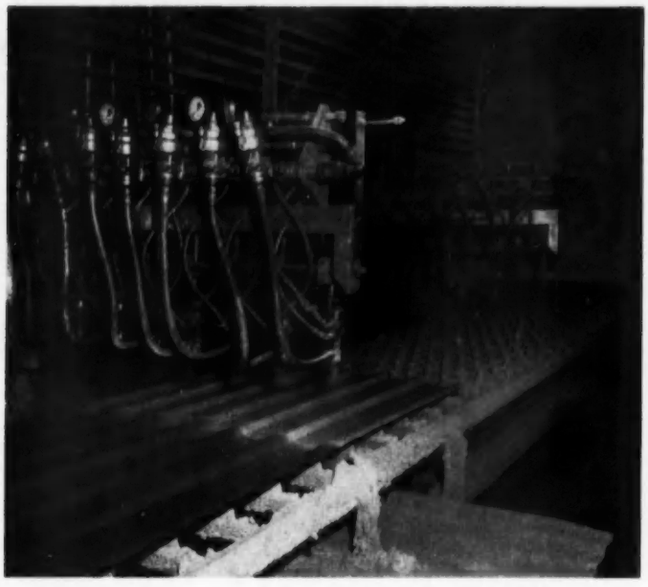
The adhesion-promoting bonding agent is a high-molecular-weight vinyl acetal resin combined with active compounds such as phosphoric acid, chromates and alcohols. It reacts chemically with the galvanised zinc coating of the panel so that excellent adhesion is assured for the subsequent finish colour coatings to be applied. At the exit end of the bond coat booth is a short enclosure which houses a fan of 4000 cubic feet per minute capacity. This large fan arrests the fumes from oncoming panels and blows them back into the bonding booth. To



Close-up view of wire brush cleaning station, with straight brushes on top and revolving brushes below the material



Bond-coated panels leaving curing oven to be loaded on a transfer bogie for travel to the finish-coating line



Interior of first finish-colour-coating booth with two sets of seven-gun sprays mounted on arms above the material

pass rigid inspection, the bond coat is applied to yield a 0·0003in thickness.

Subsequently, the panels enter a 20ft oven for bond coat curing at 300 to 350 deg. Fah. The heat source is a gas-fired burner of 600,000 B.Th.U. capacity. From this oven the panels travel directly under another fan. Then they move on to a run-off conveyor for unloading at a transfer aisle at the end of the bond coating operations. Now the panels are loaded on a transfer bogie for movement across the aisle to the beginning of the finish coating operations. They will travel over an additional 360ft of facilities paralleling the bond-coating line but running in the opposite direction.

Finish Coating

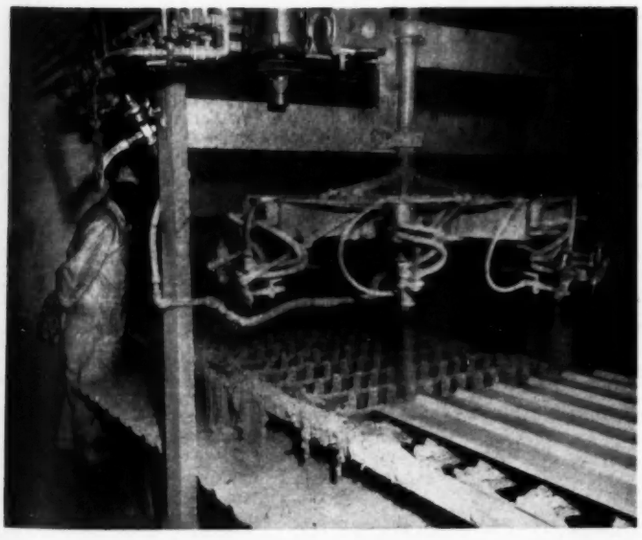
Two men place the bond-coated panels one by one on another motorised conveyor. Moving now at a speed of 80ft per minute the panels pass directly under an air-manifold spray. This removes any dust particles from the surface of the panels before they travel into a 12ft preheat oven. This oven is called upon to develop and maintain, regardless of varying outside atmospheric conditions, uniform temperatures ranging from 100 to 125 deg. Fah. The power rating of the quartz tubes generating the heat is 72kW. When the panels moved into the pre-heat oven they were transferred on to a flight-type conveyor. Moving out of the pre-heat oven they are transferred on to a flight-type conveyor for transfer into the first finish-colour-coating booth.

While travelling through this booth, the panels pass under two sets of spray guns arranged in a straight line for the application of the first two of a total of three finish coats. Actually, there are two sets of seven-gun sprays at each of the two locations. While one set of guns is applying the first and second finish coats, an additional set of guns at each location is ready for swinging into action to facilitate a quick colour change. The firm markets steel buildings in a choice of nine standard colours : two greys, two blues, two greens, white, orange and yellow. The dual set of guns at each location are mounted on two horizontal arms which turn on a shaft. Thus, one set of unused but cleaned and readied arm of guns can be quickly swung into position at each location for the application of a new colour. Simultaneously, the arms of guns that have been in production are swung free of the line for cleaning and in readiness for the next change in colour. The average colour change-over time is only three minutes. Like the guns on the bond spray arrangement, the guns in the first finish-coat booth are controlled by a memory-timer which automatically memorises and remembers the length of the panels.

After travelling through only 3ft of open space between booths, the two-coated panels enter a 16ft booth housing a carousel spray unit. The eight guns on this unit are operated individually by a memory-timer which automatically takes into account both the length and width of the panels. Each gun on the carousel spray is tied to a separate micro-trip signal. Revolving on the carousel at 40 r.p.m., the guns go on and off progressively one after another so that no gun sprays on anything except panel surface. The rotary application does a remarkable job of colour-coating the rib-type panels so that the film thickness is adequate on the flange sides too. The coatings are rigidly inspected to show a minimum of 0·00125in thickness. At the exit end of the carousel spray booth the panels are automatically transferred from a pin-type conveyor on to another flight-type conveyor for travel through a 140ft long multiple-zone oven installation. At that point another fan arrests and blows back fumes into the carousel spray booth.

Oven Drying

The multiple-zone oven system is made up of four zones. Zone 1 includes a 600,000 B.Th.U. gas burner, air movement at 3500 cubic feet per minute and three banks of 36kW infra-red tubes. Zones 2, 3 and 4 each include a 300,000 B.Th.U.



Carousel spray gun unit with eight guns revolving at 40 r.p.m. while applying finish coat

Unloading of coloured panels emerging from the multiple-zone oven at the end of the line

THE AMERICAN SCENE *(continued)*

gas burner, air movement at 3500 cubic feet per minute and two banks of 12kW infra-red tubes. The temperature of Zone 1 is maintained at approximately 275 deg. Fah. The temperature setting in Zone 2 is approximately 175 deg. Fah., and is never allowed to exceed 200 deg. Fah. The 275 deg. Fah. temperature in Zone 1 is related to the wetness of the coating on the panel. Leaving Zone 1, the coating is much drier and beginning to assume a film state. Because of the near-film state, the material must be dried from the bottom out. The temperatures in Zone 2 must be held below 200 deg. Fah. to prevent blistering of the coating. The temperatures in Zones 3 and 4 are raised to 250 deg. Fah. and 300 deg. Fah., respectively, because the drying from the bottom out was accomplished in Zone 2.

As the panels leave Zone 4 they receive a water quench from four atomising guns. This fine atomised water spray is flashed off rapidly by the heat of the panel, which, at the point of leaving the multiple zone system, is 300 deg. Fah. Leaving the 10ft water quench, the panels travel through a 50ft cooling section equipped with six 36in fans which produce 12,000 cubic feet per minute each at relatively slow speeds. Moving out of the 50ft cooling section at almost room temperature, the panels are automatically transferred from the flight-type conveyor on to a gravity-type conveyor for unloading at the end of the line.

Materials Preparation

All materials, such as colour coatings, primers and solvents, are stored and mixed in a building separate from the plant housing the colour-coating operations. Red primer is used for coating structurals and is purchased in tank-car lots and stored in two 3500 gallon tanks. In the same section, there is ample space for storing a large quantity of 50 gallon drums in which the colour coatings are purchased. The rest of the same building is housing the mixing tanks and pumping facilities for all materials used in the coating operations. It is from this section of the building that all materials are delivered to points of plant use through almost 12,000ft of a circulating piping system. In addition to the main colour-coating line, this system serves five dipping operations for small and large structural parts and a window and flashings coating line.

All standard "Stran-Steel" colour coatings are always available in the circulating system. There is also provision in the system for custom colour-coating to special order, and there is a circulating system for the bond coating. The colour coatings are mixed with solvents in twin tanks of 120 gallon capacity each. These mixing tanks draw solvents from a 12,000 gallon underground storage tank. From the 240 gallon capacity twin-tank sets, colour coatings are pumped at 80 lb to 100 lb per square inch pressure into the continuously circulating system taking the coatings out to points of plant use and back again in continuous travel.

The piping from the storage and mixing building travels into and back from the points of plant use through a heated underground tunnel. In this tunnel, special provision is made for heating to keep temperatures above 70 deg. Fah. to maintain the proper coatings viscosities. There is a screen-type filter at the exit end of each of the 240 gallon twin-tank sets containing colour coatings. These are manually cleaned every twenty minutes. White is mixed approximately to thirty seconds on a Zahn Number 2 cup. The colour coatings are run from twenty to twenty-four seconds on the same test.

Any fluctuations in air pressure could prove disastrous to the quality production standards on the main colour coating line. Therefore, an air compressor of 400 cubic feet per minute capacity serves this finishing system exclusively. As an additional precaution, indicating gauges at each spray booth are read four times daily to check the pressure of each circulating line. Throughout the working day all materials in the circulating system are kept up to pressure. Over weekends the air compressor is shut down and materials are left in the lines. In the event of a prolonged plant shutdown, the materials would not be left in the line longer than seventy-two hours. In such event, all materials would be drawn back into one of the 120 gallon tanks of the twin-tank sets. Then the other twin of the tank set would be used to pump solvents into the lines.

Window Coating Line

Ever since the firm developed factory-applied colours on steel building roofing and siding panels, it has been the ultimate goal to make available a prefabricated steel building for which no "on-the-job" painting at all will be required. Decorative parts were still being painted in the field. So, until just recently, were windows. However, the goal of completely eliminating the need for on-the-job painting became a reality at the end of 1960. A new finishing system, involving 700 lineal feet of monorail conveyor with an elevation for loading and unloading of almost 7ft is now in production at the Terre Haute works for colour-coating decorative parts and a newly designed window for steel buildings.

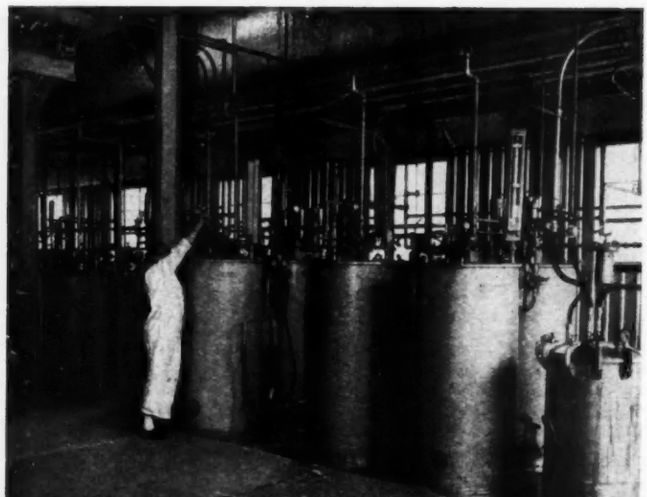
The metal parts are placed on magnetic hanging tools having a 40 lb pull. These hanging tools can be used for all the various shapes and sizes of parts involved, eliminating the necessity for having a great variety of hooks. After the parts have been hung on the magnetic hooks, the conveyor moves them into a 50ft two-stage washer. Preceded by a 7ft enclosure, the first 10ft section of this washing system houses a spray cleaner unit with pressure nozzles operating at 30 lb per square inch pressure on both sides of the material. The bath temperature of the cleaner is 160 deg. Fah., and the tank is heated with a gas-fired burner.

Prefabricated windows hanging from magnetic hooks on monorail conveyor entering the 700ft long colour-coating line

A 16ft drain board drains the cleaner solution back into the tank, while the material moves to a 10ft section of hot rinse at 140 to 160 deg. Fah. This temperature has been determined necessary for proper rinsing of the material and for promoting drying after the material leaves the washer. The first drying after cleaning is handled in two minutes at 280 deg. Fah. The 7ft enclosures immediately preceding and following the two-stage washer system house exhaust fans.

Now the material travels into a large multi-purpose drying oven. This single drying unit provides for drying following cleaning, as well as for baking the bond and colour coatings. After leaving the drying oven, the decorative parts and windows travel to the bond coat booth. The bond coat is applied by hand spray, all materials being delivered through the continuous circulating system originating from the storage and mixing building. Leaving the 14ft water wash spray booth, the flashings and windows return to the oven for a four-minute baking period and reach 280 deg. Fah. From the oven, the material moves into another 14ft booth for hand-spray application of the first colour coating. This is followed by a flash-off period of approximately three minutes. Then the material moves into a third booth for final colour coating application, again by hand spray. Hand-spraying is used all along the windows and flashings coating line because of the large variety of parts, shapes and sizes.

Following the application of the final colour coating, the parts return to the baking oven for a ten minute baking at 280 deg. Fah. The conveyor speed on the flashings and windows colour-coating line may vary from 10ft to 30ft per minute, depending upon the cleaning requirements for the parts being run. Windows, for example, require drawing compounds and, hence, a longer period of time in the two-stage washer. The firm determined that greater production efficiency would be attainable by varying the speed of the cleaning operations, rather than installing longer washing equipment. When handling materials that are not severely soiled, the line can be speeded up to 30ft per minute. This still allows ample time for oven drying to set the applied coatings prior to unloading from the magnetic hooks.



Interior of the materials storage, mixing and distribution building, with twin 120 gallon tank sets

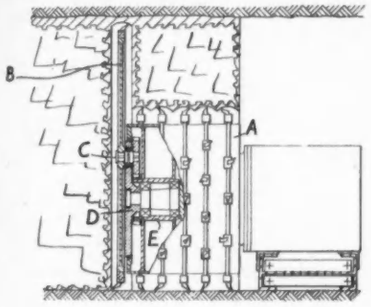
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

MINING MACHINES

857,354. June 25, 1958.—CUTTING MACHINES FOR MINES, Gebr. Eickhoff Maschinenfabrik u Eisengiesserei, m.b.H., Bochum, Germany.

It has already been proposed to cut coal by a drum cutter which makes a comparatively wide and deep cut in a coal seam and to associate with this cutter a disc cutter which is arranged deeper in the seam to form the new coal face. The diameter of the disc is usually greater than that of the drum and the arrangement is generally such that the disc cut extends over the entire height of the seam. As, in the known constructions, the disc cutter is concentric with the drum cutter and is usually mounted on an extension of its shaft, the drum makes a cut which is central in the seam and as the disc cuts a narrow kerf at one end of the central cut, a tee-shaped cut is made in the seam. This leaves uncut steps or wide ribs of coal at the floor and roof and the floor ribs interfere with the excavating operations. For example, a face conveyor can only be advanced when the floor has been cleared of the uncut coal. It is an object of the invention to provide a machine which avoids these difficulties. According to the invention a cutting machine comprises a rotatable cutter adapted to make a cut at a low level of a mine seam and a further cutter which rotates about a higher axis to make a cut which extends to or near to the roof and forms the new face of the seam. With it a drum cutter makes a cut at floor level and a disc cutter cuts a kerf which extends to roof level. It is preferred to cause the disc to cut at floor level flush with the cut made by the drum to leave a smooth floor at the new face. The drum and disc cutters rotate in opposite directions so that the reactions set up by the cutting forces partly cancel each other out. Referring to the drawing, the coal-cutting machine adapted to travel on a face conveyor is arranged to cut a coal seam by a drum cutter *A* and a disc cutter *B*.



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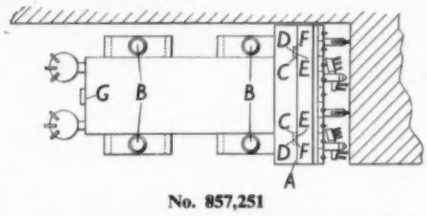
The cutter *B* is mounted on a shaft *C* rotatably mounted in a fixed end plate *D* of the drum cutter. The end plate is mounted on a fixed axle which supports the drum proper. The axis of the shaft *C* is thus higher than the axis of the axle which is the axis of rotation of the cutter *A*. The inner end of the shaft *C* wheel has fixed to it a gear which meshes with a further wheel fixed on a hub *E* of the drum proper, this hub being rotatably supported by the axle. The drive of the machine is transmitted via the hub *E* and the gear wheels to the cutter *B* so that both cutters are simultaneously driven.—*December* 29, 1960.

857,251. January 21, 1959.—MINING MACHINES, Coal Industry (Patents), Ltd., Hobart House, Grosvenor Place, London, S.W.1. (*Inventors: George Mayes Wells, Albert Edward Bennett, Eric Stanley Hotston and Laurence Reade Cooper.*)

This invention relates to controlling cutting or drilling machines for coal and other minerals. According to the invention a machine is controlled by directing an electro-magnetic radiation into the mineral through which the machine is cutting, the radiation being so directed from a point adjacent the head and so steering the machine that the amount of back-scattering of the radiation of the mineral is consistent with the head remaining in the seam. It also provides a source of radiation and means responsive to radiation back-scattered from material surrounding the machine. The coal cutting machine, which is of known design, has at its forward end a cutting head *A* and is steered from its rearward end in the usual manner by means of controls for the operation of hydraulic jacks *B*. Immediately behind the cutting head are two γ-ray sources *C* mounted on the bottom of the machine. The sources are mounted such that γ-rays emitted thereby are directed outwardly at an angle in a direction transversely across the machine. Spaced transversely of the machine with respect to each source *C* is a correspondingly one of two Geiger counters *D*. Positioned between each source and its corresponding Geiger counter is a 6in thick mild steel shield *E* which prevents direct reception by the Geiger counters of γ-rays emitted by its corresponding source. Next to each Geiger counter is a box *F* which contains the transistorised electronics necessary for supplying the h.t. current to the associated counter, and a pre-amplifier for the pulses emitted by the counters by the reception of back-scattered radiation. At the rear of the machine is indicating means *G* for indicating the amount of γ-ray radiation received by the Geiger counters. This indicating means comprises a transistorised rate meter responsive to the output of the preamplifiers and a moving coil meter calibrated in inches of coal on the floor of the seam under the machine and responsive to the output of the rate meter. The power supply of the apparatus is obtained from a transformer rectifier network (not shown) connected to the electricity supply of the machine.

For operation of the apparatus, it is necessary that about 1in of coal is left on the floor for the apparatus to detect and the machine is initially set to leave such



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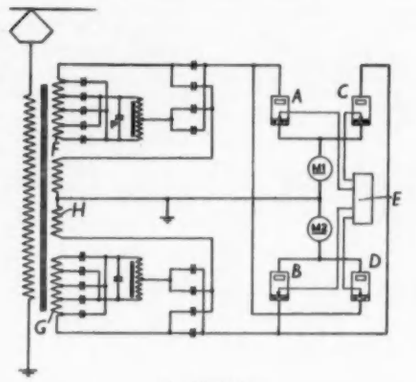
coal on the floor. The machine is, however, adjusted to cut as near the roof parting as possible. When the machine is passing through a coal seam, some of the γ-rays entering the floor of the gallery being cut by the machine will be back-scattered by the material below and will be received by the Geiger counters which will respond accordingly. As the amount of back-scattering which takes place is dependent on the density of the material in which the back-scattering occurs, it will be seen that if the machine starts to move down out of the seam more and more of the back-scattering of the γ-rays will occur in the rock formations below the coal seam and, as the rock will be denser than the coal, a variation of the amount of the radiation received by the counters will be shown on the indicating meter. Conversely, if the machine starts to move up out of the seam less and less of the back-scattering of the γ-rays will occur in the rock formations below the coal seam and, thus, an opposite variation of the amount of the radiation received by the counters will be shown on the meter. The machine can, therefore, be steered so as to maintain the indicating means such that they show that each of the Geiger counters is receiving a similar substantially constant amount of back-scattered radiation thus indicating that the machine is positioned as required in the seam.—*December* 29, 1960.

ELECTRIC TRACTION

857,332. September 12, 1956.—LOAD-SUPPLYING APPARATUS, The English Electric Company, Ltd., Queens House, 28, Kingsway, London, W.C.2. (*Inventor: Henry Bolton Calverley.*)

This invention relates to an electric circuit for supplying a d.c. load at variable voltage from an a.c. source, and finds particular application in a.c. rectifier traction vehicles. A preferred circuit applied to an a.c. rectifier locomotive is shown in the accompanying drawing, in which the transformer secondary windings feed a bridge-connected rectifier circuit, consisting of four ignitrons *A* to *D*, via tap changing contactors. The igniters of the ignitrons are connected to a variable phase grid pulse circuit generally indicated at *E* which may be of any known form. With the driver's controller in the starting position, all three secondary windings are in circuit but the windings *F* and *G* oppose the winding *H* so that the a.c. voltage applied to the rectifier bridge circuit is approximately 20 per cent of the maximum. Under these conditions the driver's controller also sets the igniter pulse circuit so that the d.c. output voltage applied to the traction motors is zero. Movement of the driver's controller towards the full speed position varies the phase of the igniter pulses applied to the ignitrons so that the d.c. voltage applied to the motors is gradually increased to a maximum when the igniters are fully advanced and the ignitrons deliver their full free-firing voltage. Further movement of the controller reduces the



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opposing voltage tapped off windings *F* and *G*, until the full voltage of winding *H* is applied to the rectifiers. All three windings are then reconnected so as to assist each other, and tap changing continues until the full voltage of the three windings is applied to the rectifier circuit. The reverse sequence is followed in reducing the voltage. Phase control may be by means of an a.c. machine with a wound rotor movable by a pilot motor; or by potentiometer control of d.c. excitation of phase-shifting reactors in the igniter circuits. As an alternative to tap-changing, an induction regulator may provide the variable a.c. voltage.—*December* 29, 1960.

WELDING

855,999. March 31, 1959.—WELDING APPARATUS, Quasi-Arc, Ltd., Bridgewater House, Cleveland Row, St. James's, London, S.W.1. (*Inventor: John Anthony Lucey.*)

When welding longitudinal seams on a number of tubes of similar cross section and size it has been found that considerable economy can be effected if the seams to be welded are presented in succession to a stationary welding head, the arrangement being such that normally it is unnecessary to interrupt the welding operation when passing from the seam in one member to the seam in the next. In such arrangements difficulty has been experienced if, for some reason, there are gaps between successive members to be welded. If these gaps are of appreciable size it is necessary to interrupt and restart welding, and it is an object of this invention to enable such stopping and restarting to be effected automatically. There is provided in proximity to the welding head a photo-electric means responsive to the presence or absence of the metal in the welding position. This photo-electric equipment is arranged to interrupt welding when there is no material in the welding position and to start and maintain the welding operation so long as material is present. The photo-electric means may be disposed in advance of the welding head.—*December* 14, 1960.

NUCLEAR ENGINEERING

857,432. June 24, 1959.—MEANS FOR SHUTTING DOWN NUCLEAR REACTORS, United Kingdom Atomic Energy Authority, London. (*Inventors: Everett Long, Frank Geoffrey Greenhalgh and Laurence Hack.*)

It is common practice to provide an emergency shut-down for nuclear reactors consisting of control rods which can fall or are projected into the reactor core, the control rods being of or containing material which has a high neutron absorption. However, if the pressure vessel ruptures, disarrangement or misalignment of the core can result, which could lead to failure of the emergency shut-down to operate. Some form of secondary shut-down is therefore desirably provided. A safety device for a research reactor has been disclosed which consists of a hopper mounted in shielding above a reactor core, the hopper containing boron-steel shot which can be released by mechanical means to fall into a well in graphite surrounding the reactor core. According to the invention, the apparatus for shutting down a reactor includes a tube removably accommodated in the reactor core, and having a releasable closure at its lower end and means for charging a number of neutron-absorbing balls into the tube. The tube is withdrawable from the core and its lower end is openable for recovery of the balls after operation. The apparatus preferably has a magazine for the balls, in which they can be held in readiness for charging. A constructional example of apparatus is described in the specification.—*December* 29, 1960.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Mon., Feb. 13.—BOURNEMOUTH AND DISTRICT BRANCH : Grand Hotel, Firvale Road, Bournemouth, Melling Regional Lecture, "Lighting—the Background of Research," S. S. Beggs, 8 p.m. ★ CENTRAL LONDON BRANCH : White Hall Hotel, Bloomsbury Square, London, W.C.1, "Operation of Reactors," A. L. Shaw 7.15 p.m. ★ NORTH WEST LONDON BRANCH : Century Hotel, Wembley, "Under-floor Heating," R. D. Jackson, 8.15 p.m.

Tues., Feb. 14.—ALDERSHOT AND DISTRICT BRANCH : Queens Hotel, High Street, Aldershot, "Electrical Testing Instruments," 8 p.m. ★ CHESTER AND DISTRICT BRANCH : Westminster Hotel, City Road, Chester, "The Application of Electricity in a Modern Waterworks," D. C. Summerton, 7.45 p.m. ★ EAST KENT BRANCH : Clarendon Hotel, Broadstairs, "Oil-fired Boilers and Associated Equipment," S. Austin, 8 p.m. ★ GLASGOW BRANCH : Kenilworth Hotel, Queen Street, Glasgow, "Telephone Equipment," 8 p.m. ★ NEWCASTLE UPON TYNE AND DISTRICT BRANCH : Roadway House, Oxford Street, Newcastle upon Tyne, "Variable Speed Motors," 7.30 p.m. ★ PORTSMOUTH AND DISTRICT BRANCH : Committee Rooms, Ministry of Labour Offices, Lake Road, Portsmouth, "Planned Maintenance," 7.30 p.m. ★ SOUTH WALES BRANCH : Park Hotel, Park Place, Cardiff, "Electrical Safety," S. J. Emerson, 7.30 p.m. ★ YORK BRANCH : Royal Station Hotel, York, "Electrical Safety in Home and Factory," F. Clark, 7.30 p.m.

Wed., Feb. 15.—NOTTINGHAM BRANCH : Mechanics Institution, Trinity Square, Nottingham, "Recent Developments in Variable Speed A.C. Motors," J. C. H. Bone, 7.30 p.m. ★ WOLVERHAMPTON AND DISTRICT BRANCH : Chamber of Commerce, District Bank Chambers, Lichfield Street, Wolverhampton, "Forensic Science and the Detection of Crime," Detective Chief Inspector Aston, 7.45 p.m.

Fri., Feb. 17.—STOKE AND CREWE BRANCH : Grand Hotel, Hanley, "Light as an Aid to Industrial Production," T. Catten, 7.30 p.m.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

To-day, Feb. 10.—WEST MIDLANDS AREA COMMITTEE : College Theatre, Coventry Technical College, The Butts, Coventry, "The Development of Science and Technology in the Future," Sir John Cockcroft, 7 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Tues., Feb. 14.—ELECTRO-ACOUSTICS GROUP : London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "Some Psycho-acoustic and Engineering Aspects of Hearing Aid Design," J. Jessop, 5.30 p.m.

Wed., Feb. 15.—SOUTH WESTERN SECTION : College of Science and Technology, Bristol, "High Speed Digital Applications of Transistors," M. L. N. Forrest, 7 p.m. ★ MERSEYSIDE SECTION : Adelphi Hotel, Liverpool, "Inertial Navigational Systems," E. W. Anderson, 7 p.m.

CEMENT AND CONCRETE ASSOCIATION

Tues., Feb. 14.—EWELL BRANCH : Ewell Technical College, Reigate Road, Ewell, "Building High," N. Wakefield, 7.15 p.m. ★ SOUTHAMPTON BRANCH : Technical College, Albert Road, Southampton, "Prestressed Concrete," H. Kaylor, 7.15 p.m.

Wed., Feb. 15.—NEWPORT BRANCH : Technical College, Hunnyhill, Newport, I.O.W., "Prestressed Concrete," H. Kaylor, 7 p.m. ★ TROWBRIDGE BRANCH : West Wiltshire College of Further Education, College Road, Trowbridge, "Surface Finishes of Concrete," F. Ward, 7.15 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Thurs., Feb. 16.—WESTERN REGION : Royal Hotel, College Green, Bristol, Discussion on "Factors Affecting the Choice of New Boiler Plant," opened by W. Short, 10.30 a.m.

DIESEL ENGINEERS AND USERS ASSOCIATION

Thurs., Feb. 16.—Institute of Marine Engineers, 76, Mark Lane, London, E.C.3, "Diesel Propulsion Machinery for Small Ships" J. B. Griffith. 2.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., Feb. 13.—SHEFFIELD CENTRE : Grand Hotel, Sheffield, Presidential Address, W. S. Stiles, 6.30 p.m.

Mon., Feb. 20.—LEEDS CENTRE : British Lighting Council, 24, Aire Street, Leeds, 1, Presidential Address, W. S. Stiles, 6.15 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Tues., Feb. 14.—SLOUGH SECTION : Lecture Theatre, High Duty Alloys, Ltd., Slough, "Developments in Melting and Casting," W. W. Glick, 7.30 p.m.

INSTITUTE OF MARINE ENGINEERS

Mon., Feb. 13.—MERSEYSIDE AND NORTH WESTERN SECTION : Newton Room, Engineers' Club, 17, Albert Square, Manchester, 2, "The Future Doxford Marine Oil Engine," P. Jackson, 6.45 p.m. ★ WEST OF ENGLAND SECTION : Small Engineering Lecture Theatre, University of Bristol, University Walk, Bristol, 8, "Recent Developments in Pump Auxiliaries for Ships," T. McAlpine and I. S. Paterson, 7.30 p.m.

Tues., Feb. 14.—Memorial Building, 76, Mark Lane, London, E.C.3, "The Design and Layout of a 22,000 s.h.p. Tanker Machinery Installation," J. B. Main, 5.30 p.m.

Wed., Feb. 15.—MERSEYSIDE AND NORTH WESTERN SECTION : Birkenhead Technical College, Borough Road, Birkenhead, "Watchkeeping and Maintenance in a Motorship," S. Speed, 7.15 p.m.

INSTITUTE OF METALS

Mon., Feb. 13.—SCOTTISH LOCAL SECTION : Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow, C.2, "Beryllium as a Structural Material," A. J. Martin, 6.30 p.m.

Thurs., Feb. 16.—BIRMINGHAM LOCAL SECTION : College of Technology, Gosta Green, Birmingham, "The Growth and Prospects of the Aluminium Industry," G. W. Lacey, 6.30 p.m. ★ NORTH EAST METALLURGICAL SOCIETY : Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, "Plastics Versus Metals," P. T. Moore and H. Hughes, 7.30 p.m.

INSTITUTE OF NAVIGATION

Fri., Feb. 17.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, Discussion on "The Admiralty Chart—II," 5.15 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., Feb. 13.—MANCHESTER AND DISTRICT CENTRE : Stephenson Room, Third Floor, Engineers' Club, Albert Square, Manchester, "Modern Vehicles for the Motorway," A. H. Carter, 7.30 p.m.

Tues., Feb. 14.—MIDLANDS CENTRE : Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, "Turbo-charging Diesel-Engined Road Vehicles," R. Tyler, 7.30 p.m.

Wed., Feb. 15.—SOUTH EASTERN CENTRE : Saracens Hotel, Ashford, Kent, "The Use of Plastics in Road Transport," G. Langford-Allen 7.30 p.m.

Thurs., Feb. 16.—YORKSHIRE CENTRE : Royal Station Hotel, York, "A Review for the Selection, Specification and Design of a Commercial Vehicle," E. B. H. Elsbury, 7.30 p.m. ★ METROPOLITAN AREA : Royal Society of Arts, John Adam Street Adelphi London, W.C.2, "Measurements of Exhaust Smoke Density from Diesel Engined Vehicles," J. D. Savage, 6.30 p.m.

INSTITUTE OF WELDING

Tues., Feb. 14.—LIVERPOOL AND DISTRICT BRANCH : City of Liverpool College of Technology, Byrom Street, Liverpool, 3, "Iron Powder Electrodes," A. B. Fieldhouse, 7.15 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Wed., Feb. 15.—Geological Society, Burlington House, London, W.1, Hinchley Memorial Lecture, "Science and the Developing Countries," P. M. S. Blackett, 5.30 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., Feb. 14.—Great George Street, Westminster, London, S.W.1, Discussion on "Safety Precautions on Civil Engineering Works, with particular reference to Recent Accidents on Bridge Construction," introduced by H. Shirley Smith, 5.30 p.m.

Thurs., Feb. 16.—TRAFFIC ENGINEERING STUDY GROUP : Great George Street, Westminster, London, S.W.1, Discussion on "The Use of Pedestrian Subways in Urban Traffic Areas," introduced by L. A. Laffan and R. A. Wright, 5.30 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, Feb. 10.—NORTH SCOTLAND SUB-CENTRE : Robert Gordon's Technical College, Aberdeen, "Subscriber Trunk Dialling," D. A. Barron, to be read by H. E. Francis, 7.30 p.m. ★ NORTH STAFFORDSHIRE SUB-CENTRE : North Staffs. College of Technology, Stoke-on-Trent, "Planning and Installation of the Sound Broadcasting Headquarters for the B.B.C.'s Overseas and European Services," F. Axon, and O. H. Barron, 7 p.m. ★ SOUTHERN CENTRE : S.E.B. Showrooms, Newport, I.O.W., "Thermo-Nuclear Physics," T. E. Allibone, 6.30 p.m.

Mon., Feb. 13.—Savoy Place, London, W.C.2, Joint meeting with the London Graduate and Student Section, Discussion on "The Road to Corporate Membership : What is the Responsible Experience Required ?" opened by A. H. Mumford, and D. S. Rolfe, 6 p.m. ★ NORTH-EASTERN CENTRE : Neville Hall, Newcastle upon Tyne, "The Protection of High-Voltage Insulators from Power-Arc Damage," A. E. Guile, 6.30 p.m. ★ NORTH-WESTERN CENTRE, EDUCATION DISCUSSION CIRCLE : Engineers' Club, Albert Square, Manchester, Discussion on "Laboratory Work for the Institution Examinations," opened by P. F. Soper, 6.15 p.m. ★ SCOTTISH ELECTRONICS AND MEASUREMENT GROUP : Royal College of Science and Technology, Glasgow, "Development of the Formulae of Electromagnetism in the M.K.S. System," P. Vigoureux, 6 p.m. ★ SOUTH MIDLAND SUPPLY AND UTILISATION GROUP : College of Advanced Technology, Gosta Green, Birmingham, "The Application of Low-Pressure Resins to Some High-Voltage Switchgear Designs," T. R. Manley, K. Rothwell and W. Gray, 6 p.m. ★ WESTERN CENTRE : Electricity House, Bristol, "The Surge Flashover Voltages of Air Gaps Associated with Insulators and Bushings," G. W. Bowdler and R. C. Hughes, 6 p.m.

Tues., Feb. 14.—EDUCATION DISCUSSION CIRCLE : Savoy Place, London, W.C.2, Discussion on "Technical Teacher Training," opened by F. T. Chapman, 6 p.m. ★ EAST MIDLAND ELECTRONICS AND CONTROL GROUP : College of Further Education, Greenclose Lane, Loughborough, "Electronic Telephone Exchanges," J. R. Pollard, 6.30 p.m. ★ BEDFORDSHIRE SUB-CENTRE : Swan Hotel, Bedford, Discussion on "Machine-Tool Control," opened by E. H. Frost-Smith, 7 p.m. ★ NORTH MIDLAND CENTRE : Lecture Theatre, Y.E.B. Offices, Ferensway, Hull, "The Characteristics and Protection of Semiconductor Rectifiers," D. B. Corbyn and N. L. Potter, 6.30 p.m. ★ NORTH MIDLAND CENTRE, EDUCATION DISCUSSION CIRCLE : Branch College of Engineering and Science, Cookridge Street, Leeds, Discussion on "The Place of the Technical Institute in the National Certificate Scheme," opened by R. L. Wilkinson, 6.30 p.m. ★ NORTH-WESTERN CENTRE : Engineers' Club, Albert Square, Manchester, "Silicon Power Rectifiers," A. J. Blundell, A. E. Garside, R. G. Hibberd, and I. Williams, 6.15 p.m. ★ NORTHERN IRELAND CENTRE : Civil Engineering Department, David Keir Building, Queen's University, Stranmillis Road, Belfast, 9, "A Survey of Street Lighting and its Future," W. R. Stevens and H. M. Ferguson, 6.30 p.m. ★ SCOTTISH ELECTRONICS AND MEASUREMENT GROUP : Carlton Hotel, Edinburgh, "Development of the Formulae of Electromagnetism in the M.K.S. System," P. Vigoureux, 7 p.m. ★ SOUTH MIDLAND CENTRE, EDUCATION DISCUSSION CIRCLE : College of Technology, Gosta Green, Birmingham, Discussion on "Courses at Technician Level on Automatic Control," opened by J. W. S. Payne, 6 p.m. ★ SOUTHERN CENTRE : Guildhall, Portsmouth, Faraday Lecture, "Transistors and All That," L. J. Davies, 6.30 p.m.

Wed., Feb. 15.—SUPPLY SECTION : Savoy Place, London, W.C.2, "A General Theory of Depreciation of Engineering Plant," D. Rudd, 5.30 p.m. ★ LONDON GRADUATE AND STUDENT SECTION : Visit to Associated Newspapers Ltd., 9.30 p.m. ★ SHEFFIELD SUB-CENTRE : The University, Mappin Street, Sheffield, "Thermisters, Their Theory, Manufacture and Application," R. W. Scarr and R. A. Setterington, 6.30 p.m. ★ RUGBY SUB-CENTRE : College of Engineering Technology, Rugby, "An Electrostatic Dust Monitor," D. H. Grindell, 6.30 p.m. ★ SOUTH-WESTERN SUB-CENTRE : S.W.E.B., Electric Hall, Torquay, "Theory of the Travelling-Wave Parametric Amplifier," A. L. Cullen, 3 p.m.

Thurs., Feb. 16.—FARADAY LECTURE : Central Hall, Westminster, London, S.W.1, "Transistors and All That," L. J. Davies, 6 p.m. ★ SOUTHERN CENTRE : South Dorset Technical College, Weymouth, "Silicon Controlled Rectifiers," D. D. Jones, 6.30 p.m. ★ IRISH BRANCH : Physical Laboratory, Trinity College, Dublin, "Research on the Performance of High-Voltage Insulators in Polluted Atmospheres," J. S. Forrest, P. J. Lambeth and D. F. Oakeshott 6 p.m.

Fri., Feb. 17.—ELECTRONICS AND COMMUNICATIONS SECTION : Savoy Place, London, W.C.2, "A Comprehensive Introduction to Plasma Physics," W. B. Thompson, 5.30 p.m.

Sat., Feb. 18.—LONDON GRADUATE AND STUDENT SECTION : Visit to B.B.C. Tatsfield Receiving and Measuring Station, Tatsfield, Kent, 2.15 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., Feb. 14.—39, Elmbank Crescent, Glasgow, "Modern Machine Tools and Production Methods," 6.30 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Wed., Feb. 15.—YORKSHIRE BRANCH : Midland Hotel, Bradford, Annual General Meeting, 7.30 p.m.

INSTITUTION OF HIGHWAY ENGINEERS

Fri., Feb. 17.—NORTH EASTERN BRANCH : Cleveland Scientific and Technical Institution, Middlesbrough, "Current Trends in Foundation Design and Construction," 7 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, Feb. 10.—EASTERN GRADUATES. SECTION : College of Further Education, Queen Alexandra Road, High Wycombe, "Mechanical Aspects of Fractional Horsepower Motors," P. G. Edkins, 7.30 p.m.

Sat., Feb. 11.—SOUTHERN GRADUATES' SECTION : Visit to the South Western Stone Company, Ltd., Portland, Dorset, 2.30 p.m.

Tues., Feb. 14.—AUTOMOBILE DIVISION : 1, Birdcage Walk, Westminster, London, S.W.1, "Initiation and Some Controlling Parameters of Combustion in the Piston Engine," J. S. Clarke, 6 p.m. ★ SOUTHERN GRADUATES' SECTION : Royal Star Hotel, Maidstone, "Racing the B.R.M.," A. F. Rivers-Fletcher, 7.30 p.m.

Wed., Feb. 15.—HYDRAULICS GROUP : 1, Birdcage Walk, Westminster London, S.W.1, Discussion on "Limitations on the Use of Scale Models of Hydraulic Machinery," opened by S. P. Hutton, 6 p.m. ★ YORKSHIRE BRANCH : Royal Station Hotel, Hull, Repetition of the Thomas Lowe Gray lecture, "The Early Development of the Dracone Flexible Barge," W. R. Hawthorne, 7.45 p.m. ★ EASTERN GRADUATES' BRANCH : Queens Engineering Works, W. H. Allen Sons and Co., Ltd., Bedford, Film Show, 7.30 p.m.

Thurs., Feb. 16.—ORDINARY MEETING : James Watt Memorial Institute, Great Charles Street, Birmingham, "Some Considerations of the Lubrication of Free-piston Machinery," R. M. Hosie, and G. M. Barrett, 11 a.m. ★ SOUTHERN BRANCH : Grand Hotel, Bournemouth, "Materials in the Service of Mechanical Engineers," R. J. Brown, 7 p.m. ★ EASTERN GRADUATES' BRANCH : College of Technology, Park Square, Luton, Film Show, 7.30 p.m. ★ NORTH EASTERN GRADUATES' BRANCH : Visit to Thermal Syndicate, Ltd., Wallsend, 5.30 p.m. ★ NORTH WESTERN GRADUATES' BRANCH : Engineers' Club, Albert Square, Manchester, "Some Aspects of Newspaper Production," K. E. Taylor, 7 p.m. ★ YORKSHIRE GRADUATES' BRANCH : Hotel Metropole, Leeds, "What Do You Know About Patents ?," T. A. Hulse, 6.30 p.m.

Fri., Feb. 17.—WESTERN BRANCH : Rougemont Hotel, Queen Street, Exeter, Informal discussion, 7 p.m.

INSTITUTION OF MINING AND METALLURGY

Thurs., Feb. 16.—Geological Society, Burlington House, Piccadilly, London, W.1, General Meeting, 5 p.m.

INSTITUTION OF PLANT ENGINEERS

Tues., Feb. 14.—BIRMINGHAM BRANCH : Hotel Leofric, Coventry, "The Increasing Use of Pack-Vending Machines," 7.30 p.m. ★ LONDON BRANCH : Royal Society of Arts, John Adam Street, Strand, London, W.C.2, Annual General Meeting, and "Under Floor Heating," 6.30 p.m. ★ MANCHESTER BRANCH : Engineers' Club, Albert Square, Manchester, "The Introduction of Planned Maintenance Systems," A. F. Stedman, 7.15 p.m.

Wed., Feb. 15.—KENT BRANCH : Queen's Head Hotel, Maidstone, "Smut Emission from Oil Fired Boilers," 7 p.m.

Thurs., Feb. 16.—MERSEYSIDE AND NORTH WALES BRANCH : The Blossoms, Chester, "The Plant Engineers' Part in Pipelining Across a Tidal River," E. Johnson, 7.15 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

Mon., Feb. 13.—EAST AND WEST RIDINGS REGION : Grand Hotel, Sheffield, "The Design of Bluebird," D. Stevens, 6.30 p.m.

Tues., Feb. 14.—BIRMINGHAM GRADUATE SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, "Shear on Press Tools," J. A. Saunt, 7 p.m.

Wed., Feb. 15.—MIDLANDS REGION : James Watt Memorial Institute, Great Charles Street, Birmingham, "The Effect of Pacing on Work Performance," N. A. Dudley, 7 p.m. ★ WOLVERHAMPTON GRADUATE SECTION : G.K.N. Research Laboratory, Birmingham New Road, Lanesfield, Wolverhampton, "Spark Erosion and its Applications," B. J. Carver, 7 p.m. ★ NORTH MIDLANDS REGION : Louis Room, St. James's Restaurant, St. James's Street, Derby, "Design of Bluebird," D. Stevens, 7 p.m. ★ NORTH MIDLANDS REGION : Conference Room, Peterscourt, Peterborough, "Agriculture and Production," P. J. Packman, 7.30 p.m. ★ SOUTH EASTERN REGION : 10, Chesterfield Street, London, W.1, "The Function and Scope of Modern Materials Handling," W. G. Rumble, 7.15 p.m.

Thurs., Feb. 16.—SCOTLAND REGION : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, Annual General Meeting, and "Some Industrial Applications of Magnetic Power," T. G. Hawker, 7.30 p.m. ★ SOUTHERN REGION : Blue Room, Reading Co-operative Society, Ltd., Cheapside, Reading, "Precision Investment Casting," P. G. Chapman, 7.30 p.m. ★ SOUTHERN REGION : Polygon Hotel, Southampton, "Materials Handling," H. P. Mott, 7.15 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

Mon., Feb. 13.—MANCHESTER SECTION : Newton Heath Technical College, Manchester, "Tyres and the Modern Car," E. S. Tompkins, 6.45 p.m. ★ MERSEYSIDE SECTION : Exchange Hotel, Liverpool, "Direct Moulded Footwear," J. G. Butlin, 7.30 p.m. ★ MIDLAND SECTION : James Watt Memorial Institute, Great Charles Street, Birmingham, "Investigation of the Ageing of Rubber Vulcanisates by Stress Relaxation Methods," J. Scanlan, 6.45 p.m.

Tues., Feb. 14.—SCOTTISH SECTION : North British Hotel, Princes Street, Edinburgh, "The Chemical Resistance of Rubber and Plastics," B. J. Habgood, 7.30 p.m. ★ LONDON SECTION : National College of Rubber Technology, Holloway Road, London, N.7, "Technological Aspects of Rubber to Metal Bonding," W. D. Rae, 5.30 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Wed., Feb. 15.—LANCASHIRE AND CHESHIRE BRANCH : College of Science and Technology, Manchester, "The Influence of Welding on Structural Design," W. Bates, 6.30 p.m. ★ YORKSHIRE BRANCH : Metropole Hotel, King Street, Leeds, "Bridge Construction," E. R. Bowers, 6.30 p.m.

Fri., Feb. 17.—SCOTTISH BRANCH : Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, "The Development of Nuclear Power in the United Kingdom," T. C. Waters, 7 p.m.

INSTITUTION OF WATER ENGINEERS

Thurs., Feb. 16.—S. EASTERN SECTION : Institution of Civil Engineers, Great George Street, London, S.W.1, Films, 2.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, Feb. 10.—Pepys House, 14, Rochester Row, London, S.W.1, "The Detection of Radiation," G. Ballard, 7 p.m.

Mon., Feb. 13.—SHEFFIELD AND DISTRICT SECTION : Livesey Clegg House, 44, Union Street, Sheffield, 1, "Punched Card Operation in Passenger Transport World," D. Eyres, 7.30 p.m.

Fri., Feb. 17.—INFORMAL MEETING : Pepys House 14, Rochester Row, Westminster, S.W.1, "Bioengineering," H. S. Wolff, 7 p.m.

NORTH EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

To-day, Feb. 10.—Lecture Theatre, Mining Institute, Neville Hall, Newcastle upon Tyne, "Heavy-Lift Vessel 'Adventurer'," C. Stephenson, 6.15 p.m.

PIPELINE INDUSTRIES GUILD

Tues., Feb. 14.—Tudor Room, Caxton Hall, London, S.W.1, "Energy on the Move," J. M. Burns, 6.30 p.m.

REINFORCED CONCRETE ASSOCIATION

To-day, Feb. 10.—SOUTH WALES AND MONMOUTHSHIRE BRANCH : South Wales Institute of Engineers, Park Place, Cardiff, "Reinforced Concrete Construction in the Coal Industry," C. A. C. Davies, 6 p.m.

ROYAL AERONAUTICAL SOCIETY

Thurs., Feb. 16.—Lecture Theatre, 4, Hamilton Place, London, W.1, Cierva Memorial Lecture, "The Era of the Autogiro," J. A. J. Bennett, 6 p.m.

ROYAL SOCIETY OF ARTS

Wed., Feb. 15.—John Adam Street, Adelphi, London, W.C.2, Peter Le Neve Foster Lecture, "The Influence of the Festival of Britain : Ten Years After," Sir Gerald Barry. 2.30 p.m.

SOCIETY OF CHEMICAL INDUSTRY

Tues., Feb. 14.—CORROSION GROUP : 14, Belgrave Square, London, S.W.1, "The Occurrence of Fire-side Corrosion in Modern Steam Generators," W. D. Jarvis and D. B. Leason, 6 p.m.

Thurs., Feb. 16.—ROAD AND BUILDING MATERIALS GROUP : 14, Belgrave Square, London, S.W.1, "An Investigation of the Properties of Mortars," G. E. Bessey, 6 p.m.

SOCIETY OF ENVIRONMENTAL ENGINEERS

Wed., Feb. 15.—Imperial College, South Kensington, London, S.W.7, "Environmental Testing of Electronic Valves," G. C. Playford and G. Radford, 6 p.m.

SOUTH WALES INSTITUTE OF ENGINEERS

Thurs., Feb. 16.—Park Place, Cardiff, "The Single Conductor Multi-Channel Signalling and Telemetering System," F. C. Riches, 6 p.m.

TELEVISION SOCIETY

To-day, Feb. 10.—Cinematograph Exhibitors' Association, 164, Shaftesbury Avenue, London, W.C.2, "Transistorised Distribution Amplifiers," B. Marsden, 7 p.m.